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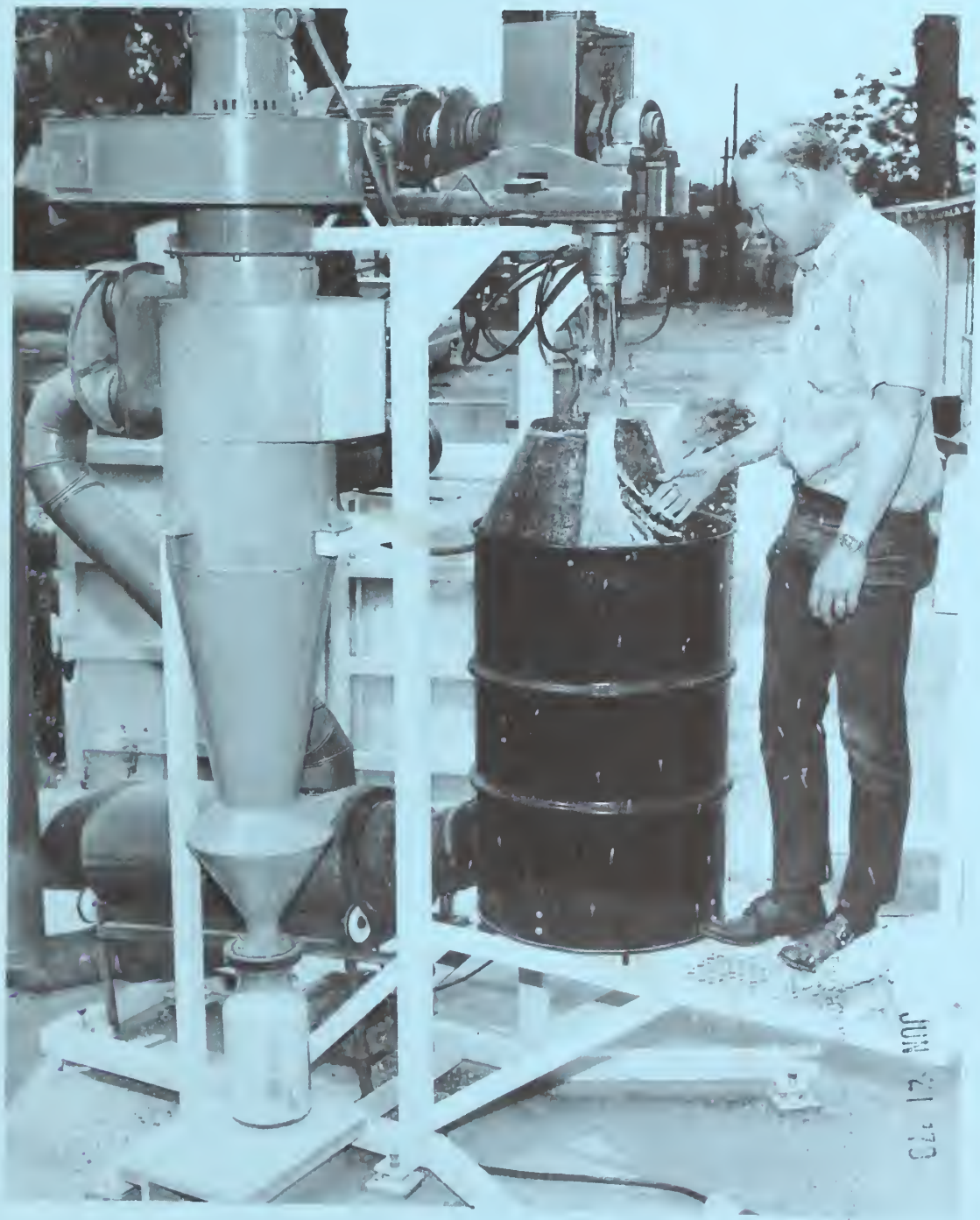

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MECHANICAL EXTRACTION OF DATE POLLEN

P. F. BURKNER AND R. M. PERKINS

Agricultural Engineer, Western Region, Agricultural Research Service,
U. S. Department of Agriculture, and Specialist, Soils Science and Agricultural
Engineering Department, University of California, respectively,
Riverside, California 92507.

ABSTRACT

Development of a commercial model of a mechanical date palm pollen extractor is described. The mechanical, vacuum system utilizes a vertical shaker for male blooms, and a cylindrical tumbler and cyclone separator system for separation of pollen from floral debris. The unit will handle 300-400 blooms /hr and recover up to 41% more pollen than manual extraction methods. Viability of mechanically extracted pollen is equal to that obtained by manual extraction. If used and scheduled properly, each commercial unit is capable of serving 800-1600 ha of palm orchard. A mechanical extractor can replace one worker in extracting pollen for 80-320 ha of orchard.

Date Growers' Inst. Rep. 52:3

Date pollen has been gathered and extracted by hand since ancient times. In the United States, manual gathering has been inefficient because the relatively few male palms are widely scattered throughout the production area. Each male palm produces 25-35 blooms that yield sufficient pollen for about 50 female palms, which at customary spacing cover an area of 0.4 ha (1 acre). Recent commercial use of mechanical pollination methods has increased the demand for pollen (2, 5).

The objective of this research was to develop a mechanical pollen extraction system that would increase the quantity of pollen recovered, maintain pollen viability, reduce labor required for extraction, and provide the operator with a clean environment.

Present Gathering and Extraction Methods

Usually, a crew of two men, using 12 m to 18 m extension ladders and a pickup truck, check the male palms two or three times per week for blooms with an open or cracked spathe. These blooms are carefully cut at the base of the stalk, placed in paper sacks after the spathe has been removed, and transported to a central area for drying and pollen extraction.

Most growers shake the blooms once by hand, while the blooms are fresh, and a second time after they have dried for 7-10 days. For the hand shaking, blooms are placed in a barrel with a shop-type vacuum cleaner connected near the bottom (Fig. 1). Part of the pollen is collected in the vacuum tank, and the remainder falls, along with parts of the flowers, to the bottom of the barrel. Later, the material in the barrel is screened to separate the pollen from the flower parts. The operator generally wears a respirator to reduce the amount of pollen inhaled while extracting pollen. Pollen is dried on trays before it is ready for use or storage.

Preliminary Investigations

There has been very little previous work reported on date pollen collection and extraction. Harries reports on a system for collecting small quantities of coconut pollen using a fluid-bed principle (4).

Our first investigations centered on the development of methods for removing the pollen from the bloom. One method consisted of passing the blooms through a series of stiff, rotating brushes (Fig. 2). The brushes removed the flowers and pollen from the blooms and this material was tray dried. Rotating brushes functioned well on partially dry blooms, but performed poorly on fresh blooms.

A cylindrical screen tumbler was then developed to remove the pollen from dried flowers. The tumbler rotated about the axis of the cylinder and was totally enclosed to prevent pollen loss. Pollen was collected in the bottom of the tumbler. We modified this system by opening the entrance to the tumbler and attaching a suction fan and bag house filter assembly to the tumbler enclosure. Pollen removal from the flower parts was improved, but removal of pollen from the filter assembly was difficult.

Experimental Model

During preliminary work, we found that a vertical shaker, similar to a date fruit shaker (1) would efficiently extract the pollen from the bloom (Fig. 3). We built a shaker that had provisions for varying the stroke from 1.3 to 15.2 cm (½ to 6 in.) and for varying the frequency from 1.7 to 26.7 Hz (100-1600 cpm).

The shaker was positioned over a 55-gallon barrel that served as a receiver for the extracted pollen and flower parts. A cylindrical screen tumbler was positioned below and on an incline to the barrel. An angled bottom with a large opening at the lower edge was put in the barrel. This opening allowed the flower parts and pollen to flow directly into one end of the tumbler. An adjustable opening at the lower end of the tumbler allowed the flower parts to flow

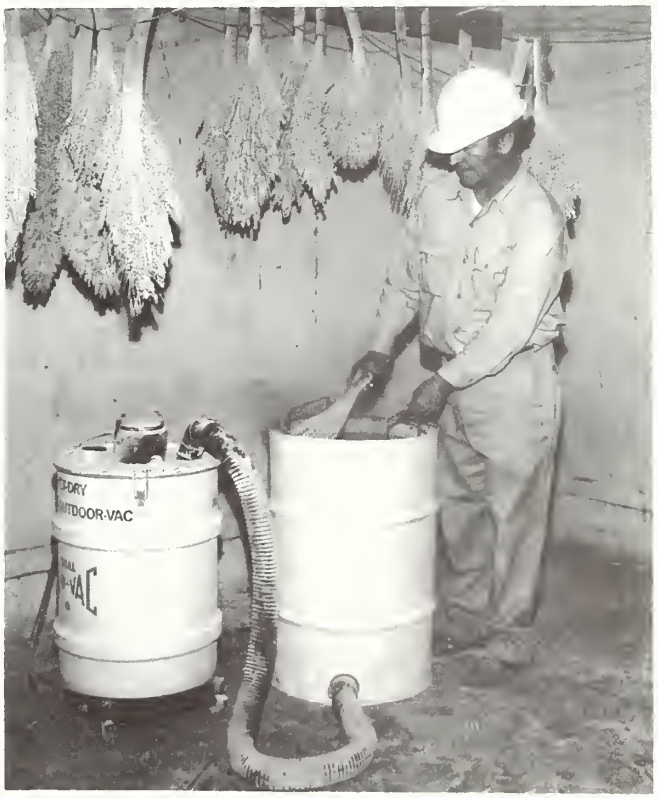

FIG. 1. Typical hand method of pollen extraction with collection barrel and shop-type vacuum cleaner. Note the amount of pollen on equipment and in the room.

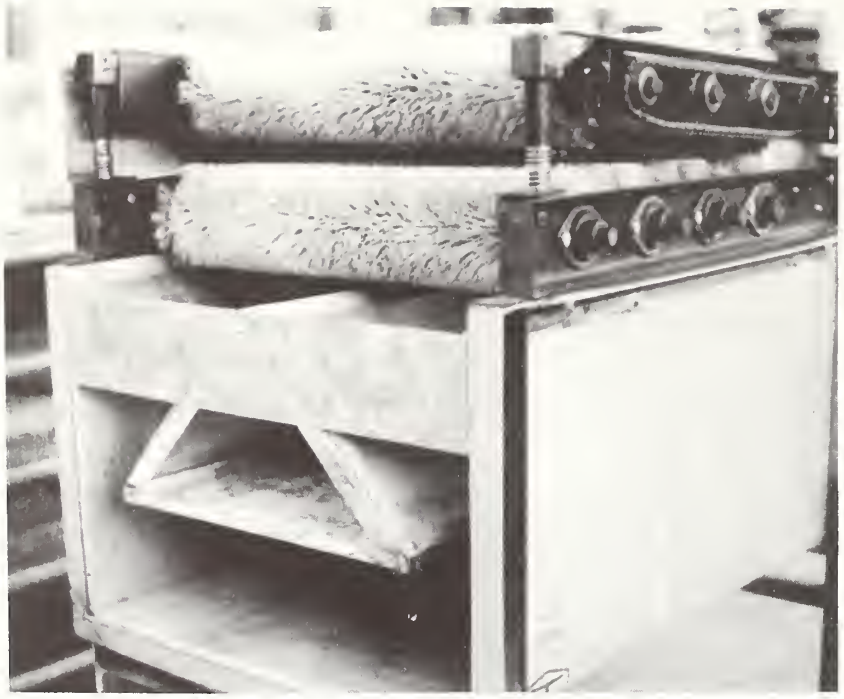

FIG. 2. Rotating-brush mechanical extractor for date pollen. The blooms pass between two rows of rotating brushes.

through and out of the tumbler. Two vacuum ducts were placed on the tumbler enclosure, one on the upper side and one on the lower side. These ducts, in turn, were connected to a cyclone separator.

Use of the cyclone separator was selected as the best method for removing pollen from the air stream. Selection of this separator was based on a pollen particle with a spherical diameter of 15-20 μ and a bulk density of .71 g/cm^3. The pollen particle is spherical when freshly harvested and ellipsoidal when dry. Particle specific gravity was estimated to be 0.95. Based on these parameters, the cyclone separator selected was one that would collect 85% of particles 8 μ in size with an airflow of 0.28 m^3/min. (600 cfm) at 1.5 kPa (6 in. w.g.).

The air outlet of the cyclone separator was ducted to the inlet of a bag house filter cabinet that contained 30 bags with a total filtering area of 13.9 m^2. All particles larger than 3 μ were retained in the filters. The filter cabinet also contained a 2.2 kW (3 hp) suction fan that provided an airflow of 0.28 m^3/min. (600 cfm) at 2.0 kPa (8 in. w.g.) for the system.

In operation, the suction fan provided airflow through the barrel, cylindrical screen tumbler, cyclone separator, and filters. While shaking a bloom, this airflow was adequate to carry free pollen and flower parts into the tumbler. In the tumbler, free pollen immediately passed through the screen and was carried by the air stream into the cyclone separator. The flower parts remained in the tumbler and received an air-washing action that removed any pollen that adhered to the flowers. After the flower parts passed through the tumbler, they passed out of the system.

The air and pollen mixture entered the top of the cyclone separator, and the pollen was collected in a jar at the bottom of the unit. The air then passed through the exit of the cyclone separator, into the bag house filter cabinet, and out through the fan. With this system, any pollen not collected in the cyclone would be lodged in the filters.

Testing Procedure

During the 1974 pollinating season, the mechanical extraction system was tested on over 2,000 blooms, and results were compared with those from the conventional hand-extraction method. Each day's harvest of blooms was randomly divided into equal-size treatments for hand and machine extraction. Each treatment was processed twice — once within 18 hr of harvest and again 7-10 days later, after the blooms had dried.

For the mechanical extraction system, we maintained records on the number of blooms shaken, the amount of pollen recovered, and the time required for extraction. The collection performance of the cyclone separator was determined by measuring the amount of pollen recovered in the jar at the bottom of the cyclone and the amount of pollen collected in the bag house filter cabinet. Cyclone efficiency was then computed from:

$$\text{Collection efficiency} = \frac{\text{Volume of pollen in cyclone} \times 100\%}{\text{Vol. of pollen in cyclone} + \text{bag house filter}}$$

Total pollen recovery was recorded for the hand-extraction method. We took random pollen samples to determine pollen viability and moisture content. Pollen viability was

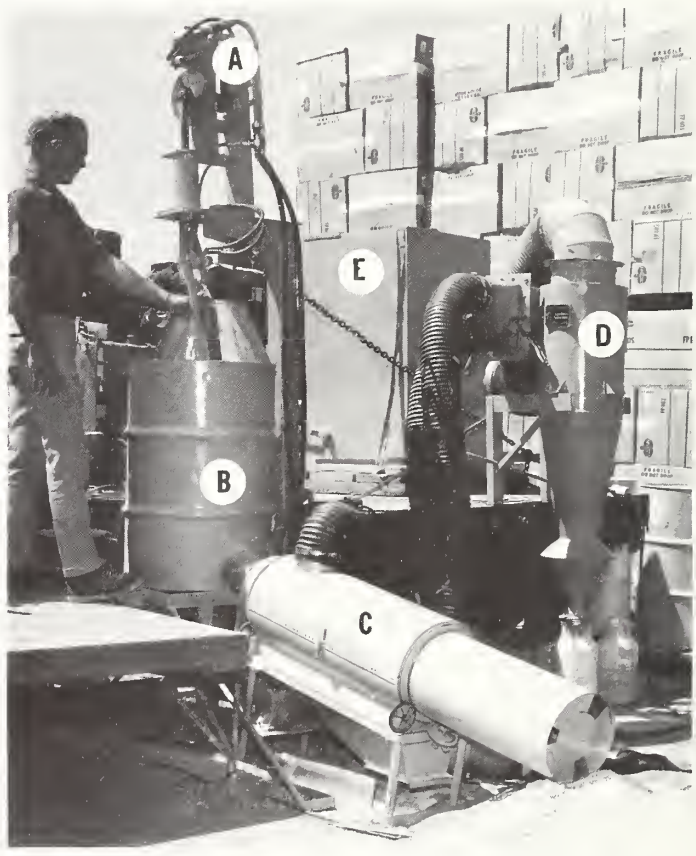

FIG. 3. Experimental shaker and collection system for date pollen. Components include: (A) vertical shaker, (B) collection barrel, (C) cylindrical screen tumbler, (D) cyclone separator, and (E) bag house filter assembly.

determined by germination of samples in a culture medium as outlined by Furr and Enriquez (3). Moisture content, dry weight basis, was determined by oven drying samples at 45° C for 6 hr.

RESULTS AND DISCUSSION

Shaker Stroke and Frequency

Testing with the variable stroke and frequency shaker indicated that a short stroke of 2.54 cm (1 in.) was preferable to the longer strokes. Frequencies between 21.7 and 26.7 Hz (1300 and 1600 cpm) at the 2.54 cm stroke removed the pollen from the bloom most effectively.

Longer strokes and lower frequencies broke flower strands from the bloom. These strands, in turn, caught in the tumbler. Lower frequencies with the 2.54 cm stroke were not vigorous enough to open some of the flowers and required a longer shaking period to remove the pollen.

Vertical shaking opened the tightly packed flower strands on fresh blooms so they dried faster than those in closed blooms (Fig. 4). Faster drying reduced the time required between the first and second shake and the incidence of mildew in the blooms.

Extraction Rate

Each bloom was shaken until pollen was no longer visibly released. For most blooms, this required 5-7 sec. The overall average extraction rate for 2,000 blooms was 8 sec/bloom, or 450 blooms/hr.

Extraction Efficiency

All the free pollen that entered the system had to be collected by either the cyclone separator or the filter assembly. Other losses could occur by pollen remaining in the discarded blooms or on flower parts after they passed through the tumbler. Visual comparison indicated hand shaken blooms retained more pollen than the mechanically shaken blooms.

In a comparison of pollen losses from the flower parts, the mechanical method was again superior. The handling of flower parts after they had passed through the tumbler left little or no pollen residue on the hands, whereas considerable residue was evident when the discarded flower parts from the hand-method of extraction were handled. For comparison, we ran some hand-shaken flower parts through the mechanical extractor. In a volume of residue that typically would be collected from the hand shaking of 100 blooms, we recovered 1.18 liters of pollen.

Cyclone Collection Efficiency

After we extracted the pollen from 1200 blooms, we collected 7 liters of pollen from the cyclone and 1.4 liters from the bag house filter. The amount collected by the cyclone represented 98% of the total recovery, or a 98% cyclone collection efficiency.

Hand Versus Mechanical Extraction

The basis for a comparison of extraction methods was the volume of pollen extracted per 100 blooms. Extraction of pollen by the mechanical system averaged 7.71 liters/100 blooms and by the hand method, 5.44 liters/100 blooms. Thus, the mechanical system yielded 41.7% more pollen than did the hand method (Table 1).

Table 1. Pollen yield for hand and mechanical extraction methods, 1974

Extraction Method	Pollen yield in liters/100 blooms		
	First shake	Second shake	Total
Hand	— — —	— — —	5.44
Mechanical	6.46	1.25	7.71

Table 2. Pollen viability for hand and mechanical extraction methods, 1974

Extraction Method	Pollen Germination, %			
	Fresh		Stored 1 year	
	Undried	Air dried	Undried	Air dried
Hand	90*	84	— — —	81
Mechanical	84	86	75*	87

*Footnoted means are significantly different from each other at the 5% level, using analysis of variance.

The mechanical system extracted most of the pollen during the first shake. The average recovery from the second shake was only 16.2%. We found that when we allowed the fresh blooms to dry 12-24 hr before they were shaken, we recovered 88% of the pollen on the first shake.

Pollen Viability and Moisture Content

There were no statistically significant differences in percentage of germination (80-90%) between the hand and mechanical extraction methods (Table 2). Germination above 80% is considered excellent.

We retested the pollen viability after 1 year's storage because the carry-over of enough pollen to start the next season is a common commercial practice. Table 2 indicates that the only statistically significant difference in viability was between fresh, undried, hand-extracted pollen and undried, mechanically-extracted pollen after 1 year's storage. Previous observations had indicated that undried pollen had reduced viability after storage.

FIG. 4. Date bloom during the shaking cycle. Note the separation and agitation of flower strands caused by shaking with a 2.54 cm (1 in.) stroke at 30 Hz (1800-cpm).

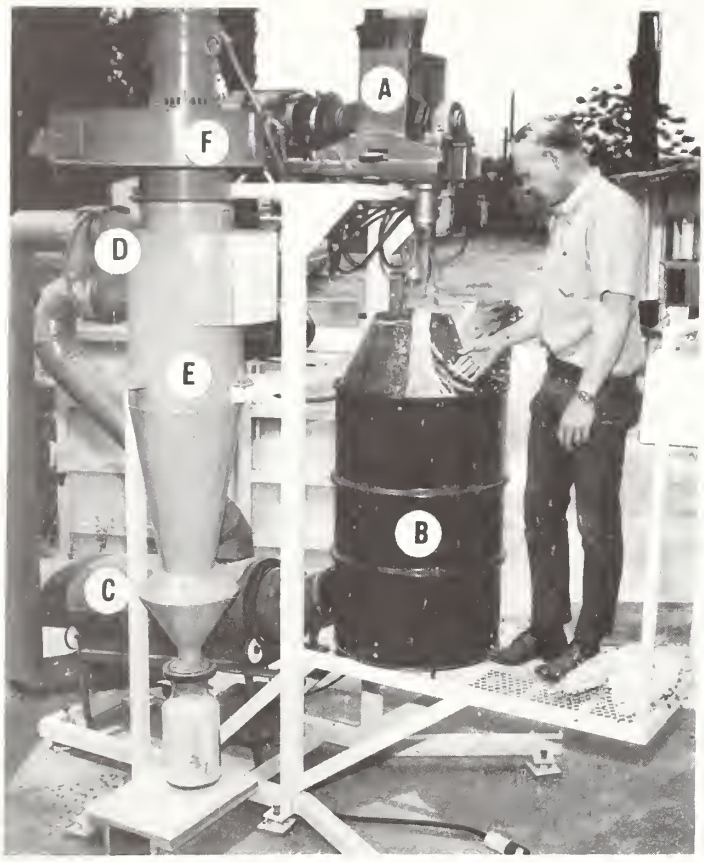

FIG. 5 Commercial model of pollen extraction and collection system. Components include: (A) vertical shaker assembly, (B) collection barrel, (C) cylindrical screen tumbler, (D) rotating screen disc assembly; (E) cyclone separator, and (F) suction fan assembly.

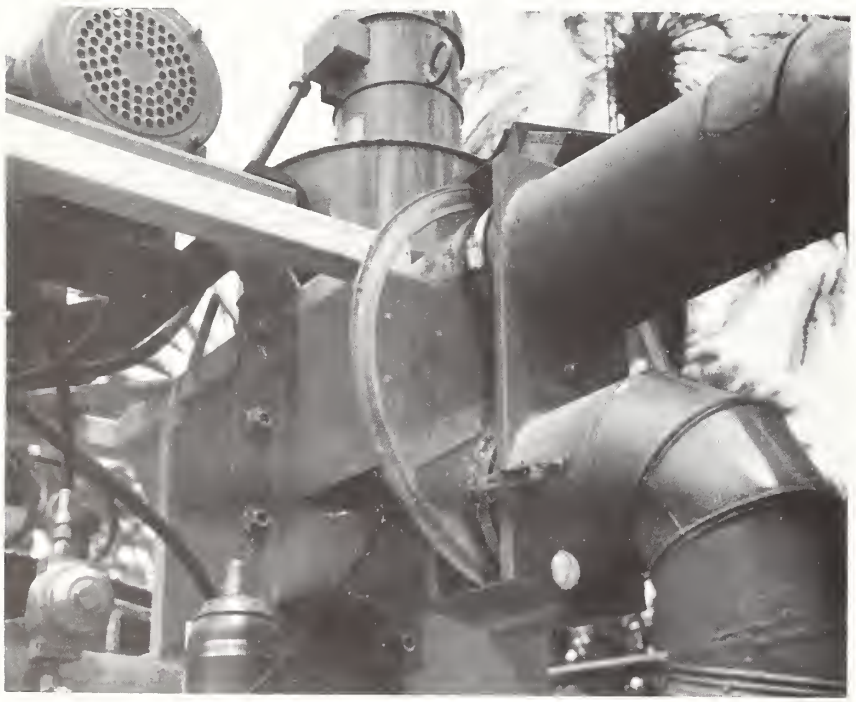

FIG. 6. Rotating-screen disc assembly. This assembly removes small flower parts from the pollen and air stream before they enter the cyclone separator.

The moisture content of fresh, hand-extracted and fresh, machine-extracted pollen was 18-25% and 12-15% dry basis, respectively. The lower moisture content of machine-extracted pollen was probably due to the increased airflow around the pollen grains during extraction and collection. We found that when the pollen was passed through the machine three times, its moisture content was reduced to 2-3%. However, as the pollen dried, more losses were incurred through the cyclone separator. Hand-extracted air-dried pollen had a moisture content of 2-4%.

Prototype Model

In 1974 we developed a prototype model for commercial use (Fig. 5). This unit was made into a single, compact assembly with all of the same components as the experimental model except for the bag house filter assembly. The filter was omitted because we felt that collection of less than 2% of the pollen that may pass through the cyclone would not justify its use.

We installed a rotating screen disc on the intake side of the cyclone separator to remove the small flower parts from the pollen (Fig. 6). The screen disc rotated continuously through the two intake ducts. Rotation made the screen self-cleaning and, therefore, did not require constant monitoring by the operator.

All of the components were mounted on a single frame. We developed a counterbalanced shaker, using standard commercial eccentrics with a 2.54 cm stroke. The shaker was driven directly by a 30-Hz (1800 cpm), 22.2 kW (3-hp) electric motor through a hydraulic clutch coupling. A small hydraulic power unit operated the clutch and bloom clamp through a solenoid valve activated by a foot switch.

During the 1975 pollinating season, four of these units were used commercially. Detailed records were maintained on one unit used cooperatively by six growers. The following is a summary of its operation:

Area served:	220 ha (550 acres)
Period of operation:	47 calendar days, 41 operating days
Quantity:	15,000 blooms
Use:	92 times, 46.2 hr
Average use per operating day:	1.1 hr
Average extraction rate:	325 blooms/hr

From this summary, the 1.1 hr use per day indicates that one unit could serve 800-1600 ha if used and scheduled properly. The average extraction rate of 325 blooms /hr compared favorably to our experimental results of 450 blooms/hr, considering that at least six operators were involved.

Labor Savings

The commercial operation of these units has also demonstrated their labor-saving capability. Two of the units were used by growers pollinating about 80 ha each. Normally, each grower employed two workers to collect and extract pollen, but with the mechanical system, only one worker was required. Another grower who pollinates about 320 ha, previously required two

workers just to extract pollen. Again, with the mechanical system, only one worker was required. Therefore, the unit saves about one worker on operations of 80-320 ha.

SUMMARY

A mechanical system that utilizes a vertical shaker, cylindrical tumbler, and cyclone separator was developed for the extraction of date pollen. The unit is capable of extracting 300-450 blooms/hr and recovering up to 41% more pollen than collected by hand-extraction methods. Pollen viability is comparable to that obtained by hand-extraction methods.

If used and scheduled properly, each commercial unit is capable of serving 800-1600 ha of palm orchard. Use of the mechanical pollen extractor has replaced one worker on operations covering 80-320 ha.

ACKNOWLEDGEMENTS

We greatly appreciate the cooperation of Charles L. Ream and Richard L. Bergman of the U. S. Date and Citrus Station, Indio, California, in conducting the pollen viability and moisture content tests.

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DATE PALM BREEDING - - A PROGRESS REPORT

C. L. REAM

Research Horticulturist, Western Region, Agricultural Research Service,
U. S. Department of Agriculture, U. S. Date and Citrus Station, Indio, California 92201

ABSTRACT

The date palm breeding project begun in 1948 has advanced as far as the fifth backcross of males with two female clonal lines and to the fourth backcross with six female clonal lines. Pollen of these males and other advanced BC lines have been used since 1970 to produce what are termed "intervarietal" crosses. More than 3,000 seedlings from 62 crosses are being grown and evaluated in field plots. Substantial flowering occurred in seedling progeny in the fourth year. Female seedlings are being evaluated to identify potentially valuable new varieties. A method of growing and transplanting date seedlings is discussed.

Date Growers' Inst. Rep. 52:8

Nixon and Furr (2) and Barrett (1) in their reports on date variety improvement have discussed breeding objectives and the problems encountered in developing new varieties. This paper is a progress report on the date palm breeding work at the U. S. Date and Citrus Station, Indio, California.

MALE PALMS. Because of the dioecious character of the date and because pure lines do not exist, one of the first objectives was to produce male palms that approach the female parent in genetic composition. Backcrossed (BC) male palms were obtained through a program in which a recurrent female parent was pollinated with a male selection from successive BC progenies. The project was started in 1948 with 35 varieties representing 48 lines. Since then, several breeding lines have been eliminated because of genetic weaknesses and by changes of emphasis in the program. At present we are growing progeny of 14 varieties representing 22 lines. A number of these are from the 4th and 5th generation backcrosses (Table 1).

TABLE 1. Recurrent female, male line number and backcross generation of male palms at U. S. Date and Citrus Station, Indio, California, 1975

Recurrent female variety	Male line No.	Backcross generation
Amir Hajj	3	3
Amir Hajj	48	1
Barhee	5	3
Barhee	6	4
Barhee	49	3
Dayri	7	3
Deglet Beida	9	1
Deglet Noor	10	5
Empress	—	1
Halawy	13	3
Halawy	14	4
Khadrawy	20	4
Khadrawy	21	4
Khalasa	22	2
Medjool	30	4
Medjool	31	5
Medjool	32	3
Medjool	33	3
Tadala	40	1
Tazizoot	41	1
Thoory	42	4
Zahidi	43	2

The fruit characters carried by the male palm are unknown, but some ideas of the transmittal of these characters may be obtained from a study of the female progeny in a backcross population. Many of the female seedlings from the third BC of 'Barhee' had fruit which closely resembled that of the female parent. 'Deglet Noor,' however, has been disappointing in this respect because none of the female seedlings from the fourth BC has fruit similar to that of the female parent.

INTERVARIETAL CROSSES. The term "intervarietal crosses," though inexact, is a convenient way of referring to crosses between female date varieties and BC male palms. The first intervarietal crosses were made in 1961 when pollen from a third BC Deglet Noor male was used to pollinate the Barhee and 'Dayri' varieties. Several additional intervarietal crosses were made in 1964, but an intensive breeding program had to await the flowering of advanced BC males. These males became available in 1970 and 1971; during this period 62 intervarietal crosses were made (Table 2). Three thousand and thirty-seven seedlings from these crosses were planted in the field in 1971, 1972, 1973 and 1974. Among these, 1,000-1,500 female hybrids should be available for evaluation. Although the number of seedling palms in each cross will be too small for detailed genetic studies, observations on fruit and growth characters should be helpful in future breeding work.

TABLE 2. Crosses made in 1970, 1971 between female date varieties and backcrossed males

Female parent variety	Different male parents (no.)
Amir Hajj	1
Badrayah	2
Dayri	8
Deglet Beida	3
Deglet Noor	10
Empress	8
Horra	2
Khadrawy	6
Kush Zebda	7
Medjool	8
Thoory	7
Total	62

PRECOCIOUS FLOWERING. Precocious flowering and fruiting of palms are of interest to the breeder because he can evaluate fruit characters at an early age. Among progeny of intervarietal crosses made in 1971, the percentage of plants in each cross flowering at 30-33 mo of age is listed in Table 3. Seed was planted in a glasshouse in December, 1971 and the palms were transplanted to field plots in June, 1972. Over one-half of the seedlings in the 'Medjool' X 'Tadala,' BC1 cross flowered in 1974 (Table 3). Some of the variation between crosses may be due to environmental factors. However, it should be noted that 36% of the seedlings in the Dayri X 'Thoory' BC3 cross flowered in 1974 (Table 3) and that Thoory was a parent in 7 and Dayri was a parent in 6 of the 16 crosses in which 20% or more of the seedlings flowered. The number, 116, of female seedlings flowering for the first time was slightly higher than the number, 94, of male seedlings that flowered.

TABLE 3. Number and percentage of progeny of intervarietal date crosses that flowered at 30-33 mo of age, number of male palms, female palms[a]

Cross	Total palms (no.)	Palms flowering			
		Total (no.)	Total %	Males (no.)	Females (no.)
Female X Backcrossed (BC) Male					
Medjool X Tadala, BC1	35	18	51	12	6
Empress X Tadala, BC1	34	15	44	9	6
Kush Zebda X Tadala, BC1	31	13	42	5	8
Thoory X Khadrawy, BC3	33	13	39	8	5
Dayri X Deglet Noor BC4	36	13	36	0	13
Dayri X Thoory, BC3	36	13	36	6	7
Kush Zebda, X Thoory, BC3	31	9	29	4	5
Thoory X Deglet Noor, BC4	33	9	27	2	7
Deglet Beida X Medjool, BC3	34	9	26	3	6
Empress X Dayri, BC2	31	8	26	3	5
Dayri X Khadrawy, BC3	36	9	25	1	8
Thoory X Tadala, BC1	34	8	24	3	5
Thoory X Medjool, BC3	35	8	23	7	1
Dayri X Tadala, BC1	36	8	22	4	4
Khadrawy X Dayri, BC2	25	5	20	0	5
Medjool X Thoory, BC3	35	7	20	5	2
Khadrawy X Thoory, BC3	32	6	19	2	4
Deglet Noor X Thoory, BC2	35	6	17	4	2

TABLE 3. (Continued)

Cross	Total palms (no.)	Palms flowering			
		Total (no.)	Total %	Males (no.)	Females (no.)
Female X Backcrossed (BC) Male					
Deglet Noor X Tadala, BC1	34	5	15	3	2
Dayri X Medjool, BC3	32	4	13	0	4
Kush Zebda X Dayri, BC2	28	3	11	0	3
Empress X Khadrawy, BC3	27	3	11	2	1
Badrayah X Deglet Noor, BC4	30	3	10	3	0
Deglet Noor X Khadrawy, BC3	32	3	9	3	0
Medjool X Dayri, BC2	34	3	9	0	3
Deglet Beida X Deglet Noor, BC4	34	2	6	1	1
Khadrawy X Tadala, BC1	32	2	6	2	0
Thoory X Halawy, BC3	33	2	6	1	1
Deglet Beida X Dayri, BC2	35	1	3	0	1
Empress X Deglet Noor, BC4	36	1	3	1	0
Deglet Noor X Dayri, BC2	32	1	3	0	1
Empress X Medjool, BC3	30	0	0	0	0

[a]Seed was planted in a glasshouse in December 1971. Seedlings were transplanted to field plots June 1972.

GROWING SEEDLINGS. Young date seedlings are difficult to transplant bareroot and the survival rate is very low. For this reason, prior to 1969, seed from the crosses was planted directly in the field. This method was not satisfactory because of weed and rodent problems, wind and sand damage, and slow early growth. Therefore, we adopted a procedure of planting the seed in pots in December and growing the seedlings for about 6 mo in a glasshouse. The first pots used were 13 cm across and 15 cm deep. These proved too shallow for good root growth. We obtained molded fiber pots which were 18 cm in diameter and 41 cm deep. By the time the plants were moved to the field, some of the roots had penetrated the sides of the pots. At planting time, the rim of the pot was broken, the sides slashed, and the pot containing the seedling was placed in the planting hole. Plant growth and survival were outstanding. Last year the fiber pots were not available. Plastic pots of the same size are being used to grow the 1974 crosses. The seedlings may have to remain in the glasshouse longer than in previous years to develop a root system which will survive transplanting when the pots are removed.

SUMMARY

The backcrossed-male breeding project which was begun in 1948 has proceeded as far as the fifth backcross with two lines and to the fourth backcross with six lines. An intensive program of intervarietal crosses was started in 1970 and over 3,000 seedlings from 62 crosses are being grown in field plots. Females from these crosses are in the process of being evaluated to select those that are potential new varieties.

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IMPROVEMENT OF NO. 2 DRY DATES WITH CELLULASE TREATMENTS[1]

DORA C. SMOLENSKY, CARL E. VANDERCOOK, WYNN R. RAYMOND AND SHIN HASEGAWA

Chemist and Research Chemists, respectively, Fruit and Vegetable Chemistry Laboratory, U. S. Department of Agriculture, Agricultural Research Service, Pasadena, California 91106

ABSTRACT

Whole No. 2 dry dates soaked in 0.1% cellulase for 2 hr at 4° C were slightly, but significantly, softer than dates soaked in water. Soaked dates were smoother and appreciably larger than unsoaked fruit. Initial rapid softening in water and in cellulase solutions suggests the action of an endocellulase. Under vacuum infiltration, cellulases of different origins gave slight differences in characteristics desirable to consumers: smoothness of skin, darkness, and translucence of the fruit. Cellulase treatments increased reducing sugar content of dates and viscosity measurements. Vacuum infiltration was superior to soaking in improving date quality.

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The No. 2 dry dates represent a significant loss to the growers when compared with natural or waxy dates. Hydration of the dry dates by soaking improves their appearance and softens them, but does not greatly improve their flavor. The original level of sugar is low (3), and the texture remains fibrous.

Research from this laboratory has indicated that cellulase is an important enzyme in the maturation and ripening process (2). When the natural softening has been arrested by premature drying, date quality can be improved by various enzyme treatments. Hasegawa, Smolensky and Maier (3) showed that, under certain conditions, cellulase can improve the texture of tough, dry date halves. Cellulase also softened whole "mixed green" dates (4). The primary problem in enzymatic treatment for the improvement of date texture is to get the enzyme to the substrate site. This paper presents some of our work on the softening of whole No. 2 dry dates by soaking and by vacuum infiltration.

MATERIALS AND METHODS

Unpitted No. 2 dry 'Deglet Noor' dates were provided by Cal Date Company, Indio, California. The following cellulases were used: Cellulase No. C-7377 (Sigma Chemical Co., activity 1.9 units/mg); Cellase 1000 (Wallerstein Laboratories); Takamine Cellulase Concentrate; Takamine Cellulase 400; and Hemicellulase C-E-100 (Miles Laboratories).

Texture was measured with a Lee-Kramer shear press, Model SP-12 IMP (L. E. E. Inc., Washington, D. C.), equipped with a stripchart recorder. The shear press was provided with a 226.8 kg (500-lb) proving ring and was calibrated against a Dillon, Model X, 453.6 kg (1000-lb) mechanical force gauge. Descent rate index was 9, and sensitivity range was 0-91 kg. The area under the force curve, used as a measure of the texture, was determined with an Ott Compensating Polar Planimeter.

Chemical determinations were made on water extracts of the dates. The dates were ground in water in a Polytron blender (Brinkman). The mixture was centrifuged, and the pellet was washed repeatedly with water. The supernatant and washings were combined and made to 500 ml with water. Total sugars and reducing sugars were measured by an automated ferricyanide method (5). Viscosity of the extract was measured with an Oswald viscosimeter at 23° C.

Moisture content of the dates was determined by drying duplicate 0.5 g samples of ground tissue under 25 mm vacuum at 60° C for 24 hr.

Soaking Study

Unpitted No. 2 dry dates were selected on the basis of homogeneity of size, color, and moisture content and were divided into two groups of 500 dates each. Both groups were soaked for 2 hr at 4° C, one group in 3 liters of water and the other in 3 liters of 0.1% cellulase. The final moisture content was about 20%. The dates were then drained for 1 hr on large wire racks and stored in sealed jars. Texture measurements were made at 16, 40 and 64 hr from draining then at monthly intervals. Experimental sets had a minimum of six halves and a maximum of eight halves for the softer dates. Eight texture determinations were made for each experiment. Moisture was determined in duplicate samples of 10 dates from each treatment.

TABLE 1. Chemical and physical changes in No. 2 dry dates vacuum infiltrated with water or 0.2% cellulase

Determination	Untreated No. 2 dry Dates	(Avg)	24 Hr. Water	(Avg)	24 Hr. Cellulase	(Avg)	3 Wk. Water	(Avg)	3 Wk. Cellulase	(Avg)	Significance of enzyme vs. water treatment at 3 wk
Reducing sugars[a]	3.96		3.44		2.77		5.41		4.94		P0.01[d]
	2.88		1.97		3.07		3.07		6.07		
	3.39	3.55	2.25	2.52	3.75	3.05	3.59	4.15	5.26	5.57	
	3.39		2.68		3.12		4.11		5.17		
	4.14		2.28		3.12		3.87		5.87		
			2.45		2.48		4.94		6.07		
Total sugars[a]	5.49		6.37		5.44		7.03		6.44		P0.05
	5.68		4.55		6.26		5.59		7.21		
	6.81	6.17	5.49	5.42	6.31	6.00	5.24	6.00	6.73	6.55	
	6.39		5.12		6.31		6.47		6.01		
	6.48		5.41		6.27		5.91		6.36		
			5.57		5.42		6.22		6.61		
RS/TS[b]	0.72		0.54		0.44		0.77		0.77		P0.01
	0.51		0.43		0.49		0.55		0.84		
	0.50	0.58	0.41	0.46	0.69	0.51	0.68	0.68	0.78	0.85	
	0.53		0.52		0.49		0.63		0.86		
	0.64		0.42		0.50		0.66		0.92		
			0.44		0.46		0.79		0.92		
Viscosity[c]	1.20		1.58		1.17		1.24		1.06		P0.01
	1.38		1.38		1.16		1.34		1.06		
	1.41	1.36	1.46	1.42	1.13	1.26	1.09	1.17	1.06	1.06	
	1.44		1.25		1.15		1.40		1.06		
	1.36		1.48		1.33		1.26		1.06		
			1.38		1.05		1.22		1.06		
Moisture	12%		24.4%		23.2%		.....		.....		

[a]Expressed in g/date from a 3-date sample.
[b]Ratio of reducing sugars over total sugars.
[c]Specific viscosity of a 3-date extract in 500 ml water.
[d] P=Probability

1) The mention of a product or company name does not imply the endorsement of the U. S. Department of Agriculture over similar products.

Vacuum Infiltration

For the desired moisture level (20-22%), the parameters of treatment time and vacuum had to be determined experimentally for each batch of dates. The No. 2 dry dates used in these experiments were held in water or 0.2% cellulase for 2 min under 203 mm of vacuum. The vacuum was released, and the dates were soaked for 2 min. They were then removed and drained for 1 hr. Figure 1 shows the final moisture content as a function of vacuum. The treated dates were stored in sealed jars for future testing.

RESULTS AND DISCUSSION

Soaking Studies

Mature dates contain hydrolytic enzymes such as cellulase, polygalacturonase and invertase, which play an important role in the softening process of the fruit (3). Figure 2 shows that the hydration of No. 2 dry dates by soaking allowed these native enzymes to function. This action reduced the shear press value to 50% of the initial value after 3 mo at 40° C. The cellulase treated samples were slightly, but significantly, softer than the water treated ones. As compared to untreated dates, soaked dates had a slightly smoother surface and were appreciably larger. Shear press values indicated that the waxy and enzyme treated dates were of equal texture and slightly softer than the water treated dates. However, the flavor and texture of waxy dates were superior to those of the treated dates. Shear press values can demonstrate textural changes within a given experiment, but do not always reflect the subtle differences in "mouth feel" experienced organoleptically.

The initial rapidity of softening in both

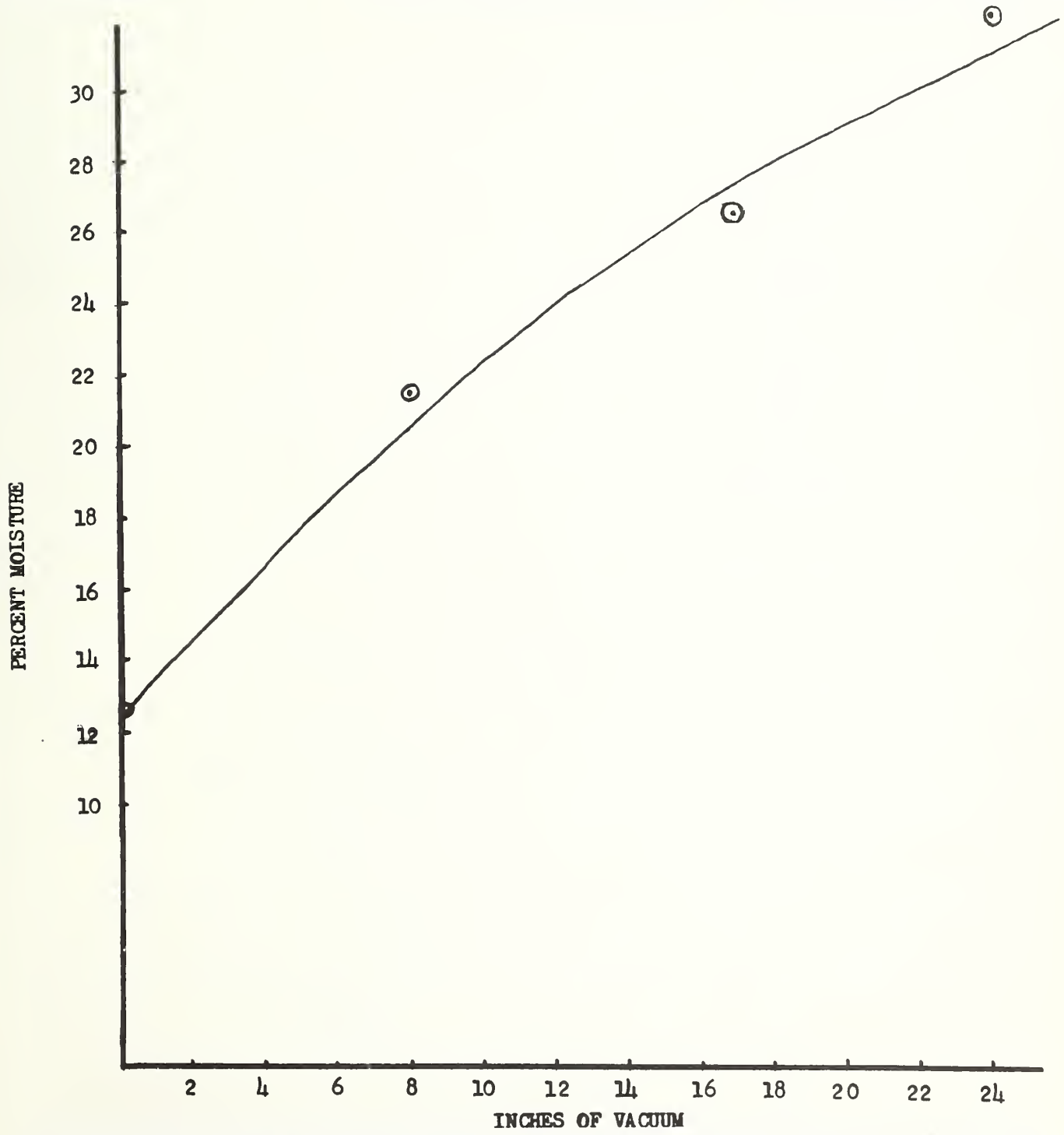

FIG. 1. Effect of vacuum on final moisture content of No. 2 dry dates. Dates covered with water, were held under vacuum for 2 min. They were soaked for 2 min after releasing the vacuum and then drained.

the water and enzyme treated dates suggests the action of an endoecllulase. Cellulase is widely recognized as a group of enzymes that catalyze the hydrolysis of eellulose to soluble earbohydrates. The initial reaetion is considered to be the enzymatie breaking of the longer eellulose ehains (by endocellulases). Other enzymes hydrolyze the intermediate and shorter length ehains.

Vacuum Infiltration

In a preliminary study to evaluate several eommereial eellulases, dates were vaeuum infiltrated with 0.2% solutions of Cellase 1000, Takamine Cellulase Coneentrate, Takamine Cellulase 400, C-E-100 Hemicellulase, and water. After 1 mo at room temperature, the taste and appearanee of all treated dates were quite similar. There were slight differenees in the follow-

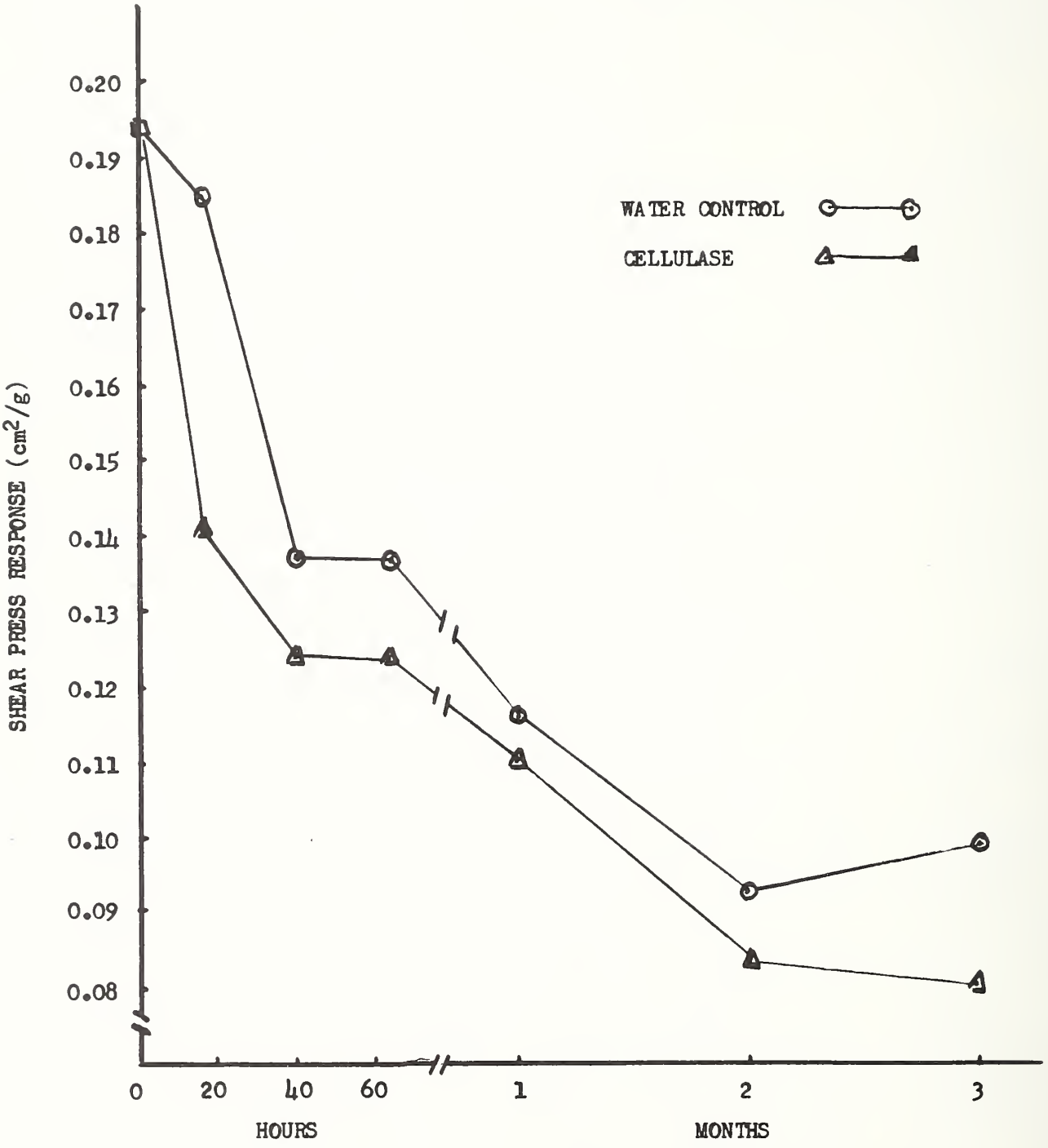

FIG. 2. Shear press response during storage of No. 2 dry dates that had been soaked 2 hr in water or in 0.2% cellulase.

ing characteristics desirable to the consumer: smoothness of skin, and darkness and translucence of the date. On the basis of these criteria Takamin Cellulase Concentrate was selected for further studies.

The effects of Takamin Cellulase Concentrate were evaluated by measuring increases in reducing and total sugars, and decreases in viscosity of water extracts. The results are summarized in Table 1. Each experimental set contained 80 dates randomly selected from a uniform batch of No. 2 dry dates. Each treatment was duplicated, and triplicate 3-date samples were extracted for the analyses. Reducing sugars in both water control and cellulase treated samples increased significantly. Native enzymes such as invertase, cellulase and polygalacturonase presumably contributed to the increases. By 3 wk, water and enzyme treated samples were significantly different at the 0.01 probability level with respect to reducing sugars; apparently the added cellulase increased the hydrolysis of the cellulose molecules to such sugars as glucose and maltose. Also, the added cellulase clearly affected the viscosity measurements. The patterns of viscosity changes during incubation of both the water and cellulase treated samples were typical of those for the enzymic breakdown of macromolecules rather than chemical hydrolysis.

The flavors and textures of the vacuum infiltrated and soaked dates were compared after a long-term cold storage (1 yr, —18° C). Dates that had been infiltrated with either cellulase or water were smooth and tender, and tasted very much like "natural" grade dates. The soaked dates, even though soft, had a more fibrous and slightly tough texture.

CONCLUSIONS

Cellulase has a significantly greater effect on the texture and chemical composition of dates than water alone. However, their shear press values and chemical composition do not completely describe our physical and taste sensations of dates. The laboratory evaluations must be supplemented with organoleptic ones. No. 2 dry dates appeared to be improved more by vacuum infiltration with cellulase than by soaking in the same solution.

ACKNOWLEDGEMENTS

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WATER AND SALINITY PROBLEMS OF ABADAN ISLAND DATE GARDENS

J. R. FURR

Formerly Research Horticulturist, United States Department of Agriculture, Agricultural Research Service, U. S. Date and Citrus Station, Indio, California 92201.

ABSTRACT

Irrigation and drainage problems associated with date palm culture in Abadan Island and some adjacent areas in Iran include high water table, irrigation with tidal water that is increasing in salinity, and poor soil aeration. The depth of the water table and the salinity of the ground water strongly influence the growth and yield of date palms. Average estimated yields of 75 kg/palm occur at the northwestern end of Abadan Island where the water table and salinity are relatively low, as compared to yields of 5 kg/palm in the vicinity of Gosbeh, where water tables and salinity are high. Estimated consumptive use of water by date palms is about 29,000 m^3/ha/yr. Extra water is required to leach away excess salts in drainage water. Recommendations are given to improve irrigation, drainage, fertilization, and other cultural practices. The date variety 'Saamaran' accounts for 80% of the production; eight other varieties are of less importance. 'Barhee' palms develop the bending head disorder.

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In the fall of 1974 I was employed as a consultant on date culture by SWECO, a Swedish engineering group engaged in the planning of an irrigation system designed to solve the irrigation and salinity problems of Abadan Island and some land along the Bahmanshir and Karun rivers, a total of about 27,000 ha. A canal to divert fresh water from some distance up the Karun River to the Abadan Island area was being planned. I was asked to make a brief survey of the Abadan Island date industry, study the available reports of work on the problem, estimate the water requirements of dates on Abadan Island, and make comments or recommendations on salinity and general cultural problems as seemed appropriate. I obtained helpful information from unpublished reports by H. Javadi[1]; M. R. Fatemi[2]; M. R. Fatemi and A. Shokrallih[3].

Abadan Island in Southwestern Iran at the head of the Persian Gulf is a long, narrow area of about 50,000 ha in the delta of the Shatt-al-Arab and the Karun River. It is bounded entirely by water — on the west, the Shatt-al-Arab; on the north, the Haffar Channel, which connects the Shatt-al-Arab and the Karun River; on the east, the Bahmanshir River; and on the south, the Persian Gulf. Abadan Island is low and flat. The land surface has an average elevation of about 13 m, which is about 3.5 m above mean tide, and a slope of less than 5 cm per km toward the Persian Gulf. The Shatt-al-Arab and the Bahmanshir River are estuaries in which the range in water level varies 2.5-3.0 m as a result of the rise and fall of the tides.

About 20,000 ha of the Abadan Island area are planted to crops, principally the date palm. The total number of palms, bearing, non-bearing, and male, is estimated to be about 6,000,000. Dates are planted in belts of varying width along the river estuaries, and most of them are irrigated by the tidal flow of water in and out twice a day through a system of canals and ditches extending from the estuaries into the gardens. Only rarely, however, as a result of extraordinarily high tides, is the soil surface of the gardens flooded. Usually, as the flood tide raises the water level in the estuaries and canals, water flows into the narrow ditches between the rows of palms, raising the ground water table slightly, but wetting little of the soil surface of the gardens. As the tide ebbs, water drains from the ditches, lowering the ground water table slightly. The mean depth of the water table below the soil surface of the gardens varies from a few centimeters in the lower parts of the Island to over 1 m in the more elevated areas. The rainfall occurs between November and April, averages about 17 cm/yr, and is of little significance in the water supply of the gardens.

The oil and shipping industries, centered respectively at the cities of Abadan on the Shatt-al-Arab and Khorramshahr on the Haffar Channel, are the most important economically in the Abadan Island area, but the date palm provides the chief support of the agricultural population of the area. The date is a staple article of the farmer's diet and is also his principal cash crop. Abadan Island is owned by the Iranian Government and the land is "endowed" to the farmer, who is charged a small fee for each date palm on his farm. Palms per ha vary from about 200 to 400, bearing trees usually being about 200. The average farmer owns about 500 palms.

Abadan Island Soils

The soils of Abadan Island are fine-textured. Some top soils are moderately permeable clay loams or silty clay loams, but most of the soils are deep silty clays and clays that, when moist, are highly plastic and of low permeability. They swell when wetted and crack when dry. The silty clay subsoils are said to be 20 m or more in depth (8). The saturation percentages of some soil samples found to be 50-84% indicate that the field moisture capacity range may be about 25-40%. The amount of water available to plants that can be held or stored in these soils is probably equivalent to a depth of approximately 15 cm/m. This water storage capacity should allow for considerable latitude in the length of intervals between water applications.

The Salinity Problem

Periodically for many years the salinity of water in the Shatt-al-Arab and Bahmanshir estuaries increased sharply during years of drought and low discharge of fresh water from the rivers that empty into these estuaries. In recent years, more and more water has been diverted for irrigation and other uses upstream, the average annual discharge of water from the Tigris, Euphrates and Karun rivers has decreased, and the intrusion of salt water from the Persian Gulf into the estuaries has increased. The problem is aggravated by the fact that the intrusion of salt water into the estuaries is greater during a rising tide, when water is flowing into the gardens, than during a falling tide, when water is flowing out of the gardens. A few farmers have taken advantage of the fact that the salinity of the river water is lowest at low tide and have installed pumps, which they operate during low tide. This is feasible only for farms near the river banks.

The average annual discharge of water from the Tigris, Euphrates and Karkeh rivers into the Shatt-al-Arab before upstream diversions were made was estimated by Gholizadeh and Peterson (8) to be about 2,000 m^3/sec (cumecs) and in 1960 to be about 670 cumecs.

In 1959, total soluble salts in the Bahmanshir River and Shatt-al-Arab reached 11,000 ppm (8), and each year since have at times reached concentrations of 5,000 ppm or more. The annual production of dates on the 20,000 ha decreased from about 140,000 metric tons in 1954 to about 72,000 tons in 1964. Average yields per tree at the upper end of Abadan Island, where water tables and salinity are relatively low, were estimated to be about 75 kg/tree as compared to 5 kg/tree in the vicinity of Gosbeh, where water tables and salinity are much higher.

In a survey of the dates of Iran, Dowson (4) described the effects of increasing salinity on date yields in the Abadan area. Gholizadeh and Petersen (8) made an extended study of the conditions there and recommended the construction of irrigation works to remedy the situation.

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Influence of Salinity on Date Production

Data from the records of the 6 ha Mehrabad Experimental Date Garden on Abadan Island show that in 1972 and 1973 the monthly average salt content of irrigation water pumped from the Shatt-al-Arab and applied by surface irrigation ranged from 619-1,015 ppm. In the same period, the salt content of samples of ground water obtained from piezometers in the Mehrabad Garden ranged from 1,000 ppm to about 4,400 ppm. The range in the salt content of the drainage water was 1,500-6,000 ppm. The conditions on the Mehrabad Garden with respect to salinity were much better than the average for Abadan Island as a whole because the irrigation water was pumped from the Shatt-al-Arab and applied to the soil surface, thus leaching salts from the soil above the water table. The average yield of dates per palm in the Experimental Garden increased from 21 kg in 1966 to 52 kg in 1971, while the average yield per palm of Abadan Island as a whole decreased from 24 kg to 16.4 kg in 1971.

In many situations on Abadan Island the ill effects of high salinity and high ground water table cannot be separated. Because of the fine texture, great depth and low permeability of the soils, the drainage system is highly ineffective; consequently, the water table stays high and soil salinity increases. The ill effects on yield of dates of the combination of high salinity and high water table are illustrated by data from the Experimental Garden. Yields of palms near piezometer stations, where the water level ranged from 72-115 cm below the soil surface and the salinity of ground water was in the range 2,000-2,800 ppm, were about 5 times the yield of palms where the ground water level was only 40-77 cm below the soil surface and salinity was between 5,000 and 6,000 ppm of soluble salts.

Salt Tolerance of Date Palms

Though the date palm is noted for salt tolerance, few controlled experiments have been conducted to determine the influence of salinity on its growth and salt uptake. Gholizadeh and Petersen (8) report that from the decline in yields of dates around the village of Gosbeh that began about 1954, it may be concluded that salt concentrations of over 3,000-4,000 ppm in the irrigation water for prolonged periods are injurious to date palms.

Because of the considerable difficulties involved in salt-tolerance experiments with date palms in full bearing, nearly all experiments have been conducted with small seedlings or young trees grown from offshoots. Furr and Ream (6) grew date seedlings in pots of peat moss and sand. The control cultures were watered with nutrient solution alone; the others, with nutrient solutions containing 3,000 to 24,000 ppm of salt, mostly chlorides. The growth rate of leaves of plants that received nutrient solution containing 1,250 ppm of soluble salts was 7.5 mm/day. Leaves of plants watered with solution containing 24,000 ppm of salt grew 1 mm/day. Growth was depressed on plants watered with solution containing 3,000 ppm of salt, and the depression of growth was nearly linear from 3,000 ppm of salts to 24,000 ppm. There were no visible symptoms of salt injury except the gradual dwarfing of the plants with increasing salt concentration.

These results illustrate the general principle that above some relatively low salt concentration, the injurious effect of salinity on plants becomes gradually greater as the salt concentration in the soil increases. The growth rate of seedlings receiving 12,000 ppm of salts was slightly more than half that of plants receiving only nutrient solution.

In a field test with young, non-bearing 'Deglet Noor' and 'Medjool' palms, Furr, Ream and Ballard (7) found that palms in plots that received irrigation water containing 6,000 ppm of salts, mostly chlorides, grew at about one half the rate of the controls, which received water containing 253 ppm of salts.

Palms that received water containing 12,000 ppm of salts grew at about one-fifth the rate of the controls. Although the plots were irrigated once a week in summer, some salt accumulated in soil in the root zone.

The average electrical conductivity values (ECe) of the saturation extracts in millimhos per centimeter at 25° C of samples from the second foot of soil taken just before each irrigation during the test were: control, 1.2 mmhos/cm; the plot receiving water with 6,000 ppm of salt, 19.3 mmhos/cm; and the plot receiving water with 12,000 ppm of salt, 31.2 mmhos/cm.

In the two salinity tests with dates mentioned above, the leaves and roots were analyzed for sodium and chlorine. The fact that accumulation of these ions in the tissues was not much greater at high than at low salinity levels shows that date roots have remarkable ability to exclude sodium and chlorine from intake with the water absorbed.

The U. S. Salinity Laboratory Staff (11) reported that the yield of barley, one of the most salt-tolerant field crops, when grown in soils with ECe values of about 16 mmhos/cm was reduced about 50%. The Salinity Laboratory Staff pointed out that climatic conditions may profoundly influence the reaction of plants to salinity. Since barley is grown in the cool season and dates make most of their growth in hot weather when salinity has the most adverse effect on plants, it seems apparent that the date palm is more salt tolerant than barley and may be the most salt tolerant of all crop plants.

In studying the influence of soil salinity on plant response, average values for soil salinity may be quite misleading, since the plant tends to absorb water through the roots in soil having the lowest total moisture stress. In a recent study of leaching requirement with alfalfa, Bernstein and Francois (1) found that the response of alfalfa was governed not by average soil salinity, but primarily by the salinity of the irrigation water. This may be a factor of considerable importance where a saline ground water table is present or where leaching is not uniform.

Consumptive Use and Water Requirement

One of the most urgent requirements of the Abadan Area Irrigation Scheme was a reliable estimate of the consumptive use, or evapotranspiration, of date palms under Abadan Island conditions. The mean monthly temperatures of Abadan Island in summer are only slightly higher than in the Coachella Valley, but the winds in Abadan are very strong and of longer duration than in Coachella Valley. The mean annual evaporation rate from a standard U. S. Weather Bureau type A pan in Indio, California is 2,525 mm, while in Abadan it is 4,605 mm. The rate of loss of water from the palms is probably not as greatly influenced by wind as is the evaporation rate from a free water surface. However, the water requirement of dates at Abadan will undoubtedly be greater than at Indio.

Consumptive use of water by dates at Abadan has not been measured. In 1966-1967 the measured amount of water applied to dates at Mehrabad Experimental Garden was 36,000 m^3/ha/yr. Gholizadeh and Petersen (8) estimated consumptive use by dates on Abadan Island to be about one liter/sec/ha, or 31,536 m^3/ha/yr. Fatemi[2] estimated consumptive use of Abadan palms to be 1.13 liters/sec/ha, or 35,635 m^3/ha/yr. The basis for these estimates was not indicated, but they are probably based upon amounts of water applied in the Abadan area. By means of soil sampling, Pillsbury (9), determined transpirational use of Deglet Noor palms in the Coachella Valley to be about 6 ft/yr, or 18,300m^3/ha/yr. Furr and Armstrong (5), also using moisture determinations of soil samples, found consumptive use of Khadrawy palms at Indio to be about 5 ft/yr, or 15,250 m^3/ha/yr. By these estimates, with an irrigation efficiency of 70% in the Coachella Valley, the water requirement of Deglet Noor palms would be 26,140 m^3/ha/yr., and that of 'Khadrawy' would be 21,785 m^3/ha/yr. At Yotvata, Israel, where the evaporation rate from a type A pan is about 3,500 mm/yr, Reuveni (10) estimated from measured applications of water that the water requirement of Deglet Noor palms is about 200 m^3/tree/yr. If the trees were spaced 9x9 m, the water requirement would be 24,690 m^3/ha/yr.

Under present conditions of water tables close to the soil surface in the Abadan area, there seems to be no means of making a reliable measurement of consumptive use of water by dates. One must, therefore, depend upon an estimate based upon measurements in other areas.

Estimates of consumptive use of water by various crops made by means of the Blaney-Criddle formula (2) have served well over quite varied areas, provided the "K" coefficient was derived from measured consumptive use by the crop in question. As the basic estimate of consumptive use of water by dates in the Abadan area, I calculated the potential consumptive use by the Blaney-Criddle formula, using a "K" coefficient of 1.2 derived from consumptive use data obtained on dates in California. By this formula the calculated annual consumptive use of water by dates in Abadan amounts to 2,400 mm depth of water, or 24,000 m^3/ha/yr. Because of the possible effect of the strong winds of long duration, the consumptive use estimate was increased by 20% to 28,806 m^3/ha/yr. To this figure should be added the amount of water needed in excess of consumptive use to leach excess salts away in the drainage water. This leaching requirement is based on the salt content of the irrigation water and the acceptable salt concentration of the water percolating at the lower level of the root zone. The Abadan Area Irrigation Scheme will deliver water of an average estimated salt content of 1,000 ppm. A leach-

ing requirement of 33% calculated on the total consumptive use figure would maintain a salt content of drainage water of about 4,000 ppm. The water needed for consumptive use and leaching amounts to 38,402 m^3/ha/yr. This is a depth of 3.84 m/yr. If this amount of water is used with an overall efficiency of 70%, then the total annual water requirement for the Scheme will be 54,800 m^3/ha/yr., a depth of about 5.48 m/yr.

Irrigation Methods

Under the proposed irrigation scheme for Abadan Island, water will be delivered to farms from lateral canals at sufficient elevation to provide for surface irrigation. The old system of canals and ditches will be filled in except as some may possibly be used for drainage. In some instances, drains may be provided with butterfly valves that open during ebb tide and close with the beginning of flood tide. In other instances, high water tables will necessitate pumping drainage water from sumps into the estuaries.

Irrigation authorities recommend flood irrigation if salinity is a problem. Also, flooding is especially desirable in irrigating soils of such fine texture and low permeability as those of Abadan Island. I recommended the construction of long, narrow basins of zero grade between the rows of trees, so that the borders would be constructed along the tree rows enclosing the base of the tree trunks. With such basins alternate middles could be irrigated on alternate irrigation dates, thus providing a relatively dry middle for orchard operations most of the time. In the Abadan Island area such large amounts of water must be applied that high and sturdy borders around basins are needed so that heavy applications of water may be made at each irrigation. I recommend the construction of basins with heavy, permanent borders to simplify the problem of applying large amounts of water to these soils with high water-holding capacity and low permeability and to avoid the serious runoff problems likely to be encountered with the use of furrows in such soils. The Abadan Island farmers have had little experience with surface irrigation, and the inception of the new irrigation scheme will confront them with some unfamiliar and difficult problems. The old tidal method of irrigation offered no problem of determining when to irrigate, how much water to order, or for how long, or how to handle the flow of water at night. Date roots obtained water from the soil wetted by the ground water table or from soil wetted by lateral movement along the ditches. Only the small plantings of side crops such as vegetables or alfalfa under the palms were irrigated by pumping or lifting water in some manner from ditches to the surface of shallow basins or into shallow furrows.

Abadan Island farmers usually allow the soil to dry out during harvest in order to pick the fruit and, in part of the garden each year, to dig up the soil to a depth of 25-30 cm. I recommended that this practice be continued, but pointed out that the critical period for water supply to dates extends from bloom to the khalal stage while fruit is green and growing rapidly. During this period of rapid growth of green fruit, water supply should be ample if fruits are to attain maximum size and be free of such troubles as hard-end and shrivel.

Water Table and Drainage

It is possible and not unlikely that in some parts of Abadan Island the high water table has damaged the date palms more than the high salt content of the water. Dates seem to tolerate high water table and poor soil aeration better than most trees, but the conditions on Abadan Island are especially adverse in areas of very high water table with respect to oxygen supply to the date roots. In soil that is saturated with saline water most of the time, the oxygen suppy to the date roots must be very poor because the solubility of oxygen in water is low and is reduced still further as the temperature and the salt content of the water increase. I saw many date palms in areas of high salinity and high water table that were severely dwarfed as a result of the poor soil conditions. In one place where the soil surface stayed permanently wet because of high water table, 35-year-old palms were so small that I could pick fruit from them while standing on the ground. The leaves were only 60-90 cm long and the one or two fruit bunches per tree were no larger than a man's hand. These trees had been abandoned, of course, because the few fruit produced were worthless.

A drainage system will have to be provided to maintain the depth to the water table at 1 m or more below the soil surface if the full benefits of the improved water quality are to be realized. The Iranian officials and the engineers concerned with planning the irrigation system are fully aware of the problems resulting from the high ground water table, but I do not know their plans for solving the drainage problems.

Soil Management and Fertilization

Under the system of tidal irrigation most of the surface soil in the gardens remained dry except for limited areas where side crops were irrigated by surface application of water. With the change to surface irrigation, there is danger of damaging soil structure by working or traveling over the soil when it is wet. The clays and silty clays of Abadan Island are already of low permeability so that the greatest care will be needed to avoid compaction of the soil when it is moist. It is not likely that it will be difficult to get enough water to penerate some of the soils of Abadan Island to supply the water needed by the palms and to leach salt from the soil above the water table. Compaction of such soils would add greatly to the permeability problem. In some gardens in which the top foot of soil was being spaded up when it was quite dry, soil structure seemed to be excellent. It is possible that periodic incorporation of organic material into the soil and working it only when it is dry enough to break up into large clods will maintain relatively good soil structure and permeability.

Little is known about the fertilizer requirements of date palms on Abadan Island since chemical fertilizers are ordinarily applied only to the side crops. Urea is widely used on the vegetable crops, so it is likely that date growth and yields would be improved by nitrogen fertilization. The application of 214 kg of actual nitrogen per ha (0.5-1 kg N/tree depending on tree spacing) was suggested as a minimum needed for good production.

Tree Spacing

Tree spacing in the Abadan area varies from 5x5 m to 7x7 m, or from 400-200 palms/ha. Trees are closely spaced in part because of the strong winds and in part because of some dwarfing resulting from high salinity, high water table, dense clay soil, and low nitrogen supply. Under improved soil and water conditions wider spacing of trees may be desirable.

Date Varieties

Javadi[1] estimated the percentages of the principal date varieties planted in the Abadan area as follows: 'Saamaran' 80%; 'Khadrawy' 7.8%; 'Barhee' 2.8%; 'Halawy' 1.7%; 'Farsy' 1.4%; 'Gantar' 1.2%; 'Leiloice' 1.2%; 'Dayri' 1.1%; 'Zahidi' 1.0%; and several others of less than 1%. Saamaran has several synonyms ('Sayer', Istamaran', etc.), none of which seems to be used by the Iranian growers. Planting of this variety has greatly exceeded all others because it is considered to be more tolerant to salinity and high water table than any other grown in the area and because it continues to bear profitable crops to an older age than the others. The profitable bearing life of some varieties estimated by Javadi, in years, is as follows: Saamaran 100; Dayri and Halawy 50; Khadrawy 45; Zahidi 40; Barhee 20-30. Javadi estimated present yields in kg/yr as follows: Barhee 50; Halawy 40; Gantar 35; Khadrawy 25; Dayri and Zahidi 20; Saamaran 15.

Some of the differences in yield result from choice of planting site and tree spacing. Barhee and Gantar are large trees and are given more space than some others and, being choice varieties, are given choice planting sites. Saamaran is always chosen for the worst sites. The Barhee develops the bent-head trouble (3) on Abadan Island as it does in the Coachella Valley. This often accounts for its short productive period.

Barhee sells for $0.15-0.24/kg, and Saamaran for $0.08/kg, but Saamaran will no doubt continue to be the principal variety for a long time even if soil and water conditions become favorable for other varieties because many of the Saamaran trees now planted will continue to be productive for a long time and also because most of the offshoots available now are Saamaran. Planting of Halawy and Khadrawy should increase, however, because of their desirability for export.

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NOTES ON DATE CULTURE IN THE ARAB REPUBLIC OF EGYPT, ISRAEL AND THE PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN

J. B. CARPENTER

Plant Pathologist, Agricultural Research Service,
U. S. Department of Agriculture, Indio, California 92201.

ABSTRACT

Modern date palm culture in an Egyptian Government Project at Kharga Oasis demonstrates that, with proper management, good commercial yields of dates can be obtained. Date yields in Project orchards 12 years old in 1974 were more than four times those of private, traditionally cultivated orchards. Control of insects in ripening and stored fruit is a major problem that remains to be solved. Continuous research and development provide Israel with a modern, innovative date palm industry. Investigation of drip irrigation, of mechanical cultural aids, of late khalal fruit of the 'Hayany' as a quick-frozen date for the European market, and of skin separation in 'Khadrawy' dates are some of the recent advances in Israel. In the Wadi Hadramaut district of PDR Yemen, date culture is carried on by traditional methods. Although date palms are well adapted to the Hadramaut, a frequently inadequate supply of water and fertilizer and uncontrolled insect infestation of fruit result in yields of fruit that are below commercially acceptable standards. A unique pollination practice is described in which the hand-pollinated female spadix is immediately painted with crude castor oil, purportedly to enhance fruit set and prevent shattering of young fruits.

Date Growers' Inst. Rep. 52:18

Information on date palm culture and research in the three countries, which I visited during 1974-1975, has been published infrequently by either domestic or foreign observers, except in the case of Israel. There, date palm research and improvement of cultural methods have been conducted for more than 20 years, but few foreigners have published their observations on date culture. Each country is treated separately because dates are grown under diverse cultural and environmental conditions. Generous assistance was received from many sources and is acknowledged in each section of this account. The friendliness and many courtesies of the Egyptians, Israelis and Yemenis with whom I worked or met casually made each visit informative and pleasant.

ARAB REPUBLIC OF EGYPT

The opportunity to visit Egypt in September 1974 came through a request from the Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy, for assistance with date palm and citrus programs in Kharga Oasis, where FAO cooperates with the Egyptian government through the Executing Agency for the Desert Project. Kharga is one of a chain of five large depressions and oases in the Western Desert of Egypt that comprise an area known as New Valley. The oases are distributed irregularly along a distance of 850 km from the Sudanese boundary in the south to the Quattara depression near the Mediterranean Sea. Foreign visitors and technicians require government permission to visit the Western Desert.

Although a few paved roads have been developed in recent years, the New Valley oases remain isolated from the Nile Valley and have not been on the main tourist route. A few publications (1, 3, 7, 8, 9, 11) mention traditional date culture in these oases, but, except for governmental reports, nothing has been published on the modern date culture now underway in the project at Kharga.

The villages and well sites of Kharga Oasis lie along a north-south axis that extends from 26°—24° N lat. The oasis is underlaid by excellent, deep aquifers that flow from southwest to northeast through a sedimentary formation known as the Nubian sandstone. Water from artesian and hand-dug wells has been available since at least recent geologic times and man has occupied the area since the Paleolithic period. Date culture is ancient. In locally-owned plantings, the cultural operations are traditional, minimal, and unsuitable for modern commercial exploitation. The usual problems of relatively low yield, alternate bearing, and slow tree growth result from insufficient irrigation, lack of fertilizer, and irregularly-spaced plantings of high density. Added to these are a lack of insect control and heavy infestation of fruit by insects at harvest time.

In 1959, the Egyptian government began a program, with headquarters at Kharga, to expand and modernize agriculture in the New Valley. The object was to determine whether an initial area of from 40,000-160,000 ha could be opened for colonization and could contribute to the country's overall agricultural production. Currently, 14,000 ha are being irrigated. At Kharga, 1,200 ha are under traditional irrigation and 2,800 ha are irrigated by a large number of new wells, some more than 1,000 m deep. At each suitable well site the surounding area of a few to more than 40 ha has been irrigated and planted to a wide variety of annual and permanent crops to learn the productive capabilities of that site.

Important considerations in the establishment of new agricultural sites are wind and sand. The oasis is subject to strong north-northwest winds and heavy sand drift. Dune movements of up to 15 m per year are reported. All Project plantings have external and internal windbreaks of *Casuarina sp.*, often planted in multiple rows.

Representative sites with date palms are discussed. Goumharia Farm at Kharga, the oldest site in the Project, was acquired about 1959. This farm is on the deepest soil seen and has date, citrus and olive trees 35-40 yr old. Several well sites and palm orchards are located in the Gennah area, about 12 km south of Kharga. At Gennah Well 6 and Well 12, dates, olives, guava and citrus are grown. About 40 km south of Kharga are the Bulaq well sites, which have plantings of young date palms, vegetables, and other crops. The Gormashine group of wells lies about 55 km south of Kharga. At Gormashine Well 1 and Well 12, 12-year-old date palms were studied and field crops were noted.

CENSUS AND UTILIZATION. The project date orchards comprise about 60 ha. 'Saidy' is the main variety; 'Kustawy', a dry-fruited variety of unsatisfactory quality, is planted on 3 ha at Gormashine Well 1. In 1974, the numbers of palms in local private plantings were: Saidy, 151,700; tamar (dry-type dates), 600; mantour (miscellaneous seedlings), 29,100; males, 12,600; non-productive (out of bearing and probably includes Saidy), 25,200; total palms, 219,-200.

Dates provide the principal cash crop at Kharga. About equal amounts of the crop are sold locally and exported to the Nile Valley; the fruit is also used for payment of wages. The best Saidy fruit is of high quality and attractive appearance as observed in the orchards. No packed fruit was seen. Although this visit was made too early to see packinghouse operations, Taha Khalil kindly supplied the following information. Most of the Saidy crop is processed through the packinghouse. In 1973, 517 metric tons of dates were exported to other Egyptian markets from Kharga and an equal quantity was sold locally. Fruit is sorted into two grades, marketable fruit and culls. Marketable Saidy fruit is packed in containers of ½, 1, 6 and 25 kg capacity. A small quantity of Saidy dates, perhaps 0.5 metric ton, is stuffed with almonds. Fruit of the dry tamar class is packed in 1 kg bags or in bulk containers. The reported value of Saidy dates in 1973 was about $0.10/kg paid to the grower and a market price of $0.15/kg.

YIELD. Yields were estimated in representative orchards and the data converted to a hectare basis for comparison. The orchards were not statistically comparable, but the evidence leaves no doubt about relative yields of project vs. native orchards.

Bunches per tree were counted and the bunch weights were estimated by Ahmed Amin, Horticultural Officer. At least half of the fruit was in the khalal stage, and the rutab fruit was very moist. Fruit weights per ha were reduced 15% to allow for weight loss as fruit ripened to the late rutab or tamar stages. The adjusted weights should provide a satisfactory basis for economic studies.

TABLE 1. Estimated yield of Saidy date palms in representative orchards at Kharga, Egypt, 1974

Location	Age of trees (yr)	Trees examined (no.)	Bunches		Yield		
			Total (no.)	Per tree (no.)	Total (no.)	Per tree (kg)	Per ha[a,b] (kg)
Gormashine Well 1	12	25	258	10.3	1,982	79.3	13,750
Goumaharia Farm	40	25	339	13.6	4,470	179.0	31,039
Native plantings	5-60[c]	100[d]	309	3.1	1,668	16.7	2,896

[a]204 trees/ha, spaced 7 x 7 m.

[b]15% was deducted from fruit weight. See text.

[c]Trees mostly 15-60 years old.

[d]Of these 100 trees in five good native orchards, only 55 were bearing; the other 45 trees had no fruit. Alternate bearing is common where water and fertilizer supplies are inadequate and where other cultural practices are poor.

The results (Table 1) show that private plantings under traditional culture produce poorly and are uneconomic as compared to those in modern commercial production.

The trees at Goumharia Farm are advantageously sited on clay loam 2 m or more in depth; drainage, water supply and fertilizer are adequate. All of the trees were in fruit. This block of palms had a yield comparable to the best in California. The trees at Gormashine Well 1 are 12 yr old, but their actual sizes represent a range of 7-12 yr. Yields were good for trees in this size range. Small trees and replants were not considered because they were not old enough to fruit and their inflorescences had been removed in the spring. Five-year-old Saidy palms on the best soils at other sites were growing well and often carried four to seven good, medium-sized bunches of fruit, indicating that adequate yields can he expected as the palms mature.

Yield of ten 12-year-old Kustawy palms was estimated at 42 kg/tree. This would amount to 6,855 kg/ha, after deducting 20% weight for water loss at maturity in November. Kustawy is not a good variety and the short fruit stalks make bunch management difficult.

SOIL, WATER AND FERTILIZER. Palm orchards are on soils ranging from the good soil at Goumharia Farm to poor sandy loams 1-1.5 m deep and underlaid with sandstones that may be uniform or irregular in surface. The sandstones vary from a fractured, porous substratum to a hard, impervious one that presents drainage problems. At each site visited, trees in the best areas of the orchard were making satisfactory growth, which emphasized the adaptability of date palms to a wide range of soil conditions when irrigation and fertilization receive careful attention.

Water from deep wells contains 200-600 ppm dissolved solids, of which sodium chloride and sodium sulfate predominate. However, the salts have not interfered noticeably with plant growth as evidenced by the satisfactory color and condition of citrus trees and by the growth of field crops, all of which are more sensitive than dates to saline conditions. Water is conducted by gravity from the well head, which is located at the highest point in the site, to the fields through open, rock-lined or earth ditches. Because of restricted drainage in the relatively shallow soils, irrigation is carefully controlled. Frequent, moderate amounts of water are applied to palms in a 1 m wide basin in the tree row.

Most orchards are intercropped in winter with vegetables and other crops. Young palms are watered regularly, but receive fertilizer only from the intercrops. Bearing palms are also intercropped and thus receive supplementary water and fertilizer. Palms 5 yr of age and older receive 900 g N/yr in two applications, April and June. Another 150 g N are supplied as organic matter. Irrigations are given weekly in summer and at 2-wk intervals in winter.

OFFSHOOT MANAGEMENT. Offshoots are either planted immediately after cutting or grown for 2 yr in a nursery. Reportedly, 65% of the immediately-planted offshoots survive and 85% of the nursery offshoots survive, although these figures seem too high for the young plantings that I saw.

A trial is underway at Gormashine Well 1 to determine the value, under Kharga conditions, of what is reported to be an Iraqi method for rooting offshoots. Offshoots of suitable size for transplanting are gradually severed from the mother plant by making three successive cuts in the connecting stem. The first cut was made in June, the second in July, and the final and severing cut in August. The offshoots will be left in place until February 1975 and should then be ready for transplanting directly to the field. In addition to offshoots in this test, about 3,000 Saidy offshoots were ready for cutting and transplanting to nurseries in October-November 1974.

LEAF AND BUNCH MANAGEMENT. Palms are allowed to develop full crowns of 100 or more leaves, so that leaf surface is not a limiting factor in production. Leaves remain functional for at least 3-4 yr. Palms in private orchards also carry good numbers of leaves, in contrast to the excessive leaf pruning practiced in much of the Nile Valley. Old leaves are removed at regular intervals; dethorning of the leaf rachis is not done. At the early khalal stage, each bunch is enveloped in a covering of coarse grass, reeds or straw held securely in place by strips of palm fiber. This covering acts as a ventilated basket that reduces wind shattering, retains fallen fruit, and offers protection from birds. The only disadvantage is that it may hamper thorough application of pesticides.

DISEASES AND PESTS. Palms were remarkably free of diseases of either the tree or the fruit, except for secondary fungal invasion of fruit following insect damage. No mite damage was seen, which is remarkable as mites are a major pest in most date-growing areas. Parlatoria scale (*P. blanchardi Targ.*) is widespread, but apparently of negligible importance on Saidy palms. This scale, which can be a devastating pest, at Gormashire Well 1 seemed to be more common on trees of Kustawy than on the intermixed trees of Saidy.

Good fruit set suggests that insects that infest fruit early in the season are not important. Insect control in ripening fruit is poor. Late khalal and rutab fruit was often heavily infested with larvae of Lepidoptera, probably of *Cadra* spp., and with nitidulid beetles (mainly *Carpophilus hemipterus L.*) and their larvae. Ants and large, 1-in-long, black larvae were found among fallen fruit retained in the bunch covers.

At Goumharia Farm, insect infestation of fruit was obvious. A total random sample of 335 dates from each of several bunches showed 52% infestation of rutab fruit, principally by larvae of Lepidoptera, probably *Cadra* spp. Therefore, out of an estimated yield of 4,470 kg, 2,324 kg were culls by international market standards. Furthermore, this heavy infestation presented a serious hazard to normally ripening fruit in the same tree.

The infestation at Gormashine Well 1 amounted to 16% out of a random 3-bunch sample of 566 fruit. At Gormashine Well 8, no insecticide was used this year. Examination of four bunches of Saidy showed that the rutab fruit had fallen and was nearly 100% infested with larvae and beetles, and secondary insects were feeding on rotting fruit. This infestation would doom the khalal fruit to complete infestation as it ripened. This really says that, except for another year's tree growth, the water, fertilizer and maintenance of this orchard was a waste of money.

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ISRAEL

For many years, California date growers have been aware of Israel's interest in developing a modern date industry. Numerous growers and scientists from that country have visited here, and several shipments of date offshoots have been sent from Coachella Valley to Israel. A welcome invitation to visit Israel became a reality for me in October 1974 through the generosity of the Agricultural Research Organization of the Volcani Center and of the Israel Ministry of Agriculture. The account given here was gleaned from seven days devoted to visiting date and citrus plantings throughout the country.

BACKGROUND AND STATISTICS. The vigorous, modern date industry of Israel is well supported by appropriate extension and research activities and by many intelligent growers. Date growing is confined to

irrigated sites in the low-lying desert areas along a north-south axis from the Sea of Galilee through the Bet Shean district, along the Jordan Valley to Jericho, southward along the western shore of the Dead Sea and on through the Arava Valley, culminating in plantings at Elat on the Gulf of Aqaba. An area of traditional date culture in northern Sinai was not seen. Hilgeman's (6) account provides useful background information on date culture in Israel, and numerous recent papers on date culture attest to the interest of Israeli scientists in this crop.

The modern date industry in Israel began with importation of offshoots, mainly of the 'Hayany' variety, from Egypt in 1922 and 1938. 'Zahidi,' 'Khadrawy,' 'Halawy,' 'Barhee' and other varieties were imported from Iraq from 1933-1937. In 1955, about 63,000 offshoots were imported from Iraq, through Iran; only 30% of these offshoots survived. This shipment inadvertently included many seedlings and males. The plants were grown in nurseries and from there new plantings were made in the Arava Valley from 1958-1962. Importations from the United States, principally of 'Deglet Noor' and 'Medjool' palms, were made in 1934, 1935, 1949, 1958 and 1972 to 1975. In 1952, a planting of several hectares was established at Ein Gedi, on the western shore of the Dead Sea, a few miles north of Masada. These trees, as well as those in other plantings, furnished a valuable source of planting material and also provided plants for experimental work. By 1975, date plantings derived from local trees and from imports from California were distributed by districts as follows: Bet Shean 15, Jordan Valley 7, Lower Jordan Valley and Arava Valley 14.

Palm spacing is mostly 9x9 m in new plantings, although older plantings were 10x10 m. Even closer spacing might be feasible with Medjool, which has a high conical crown, or where palms are used to border fields. A census of bearing and young date palms by varieties in the principal areas is given in Table 2.

Production figures for 1973 are as follows: Dry dates (which by Israeli standards include 'Dayri,' Deglet Noor, Halawy, Khadrawy and Zahidi).

Domestic Markets	1,300,000 kg
Export	80,000 kg
Khadrawy (on hand for early season 1974)	500,000 kg

Soft dates (Barhee and Hayany)

Domestic Markets	
Barhee and Hayany (Principally sold as khalal)	78,500 kg
Hayany, exported	330,000 kg
On hand	45,000 kg

Total, including unaccounted for varieties, approximately 2,500 metric tons.

PACKING HOUSES. The Government has no uniform standards for packing houses, so considerable variation in operation occurs. The best houses are clean and efficient with first-class facilities for fruit handling. The facilities at Yotvata appeared to be excellent, with a neat, efficient multiple-purpose packing house. Fumigation, cold-storage and other facilities were available. Date packing had not begun. At Eilot Kibbutz the packing house was functioning. The Deglet Noor and Medjool fruit was of good quality.

The Hazaith cooperative packing house near the town of Bet Shean had good facilities for fumigation, hydration, sorting and packing. There I saw Hayany handled as a khalal fruit and frozen immediately after it was received and fumigated. After about 72 hr, the fruit is graded and packed quickly into packages of various sizes. The fruit remains so cold that frost develops on some fruits in the packages still being processed. The packages are sealed and returned to the freezers. Thereafter, it is handled as a frozen food for distribution in European markets. The fruits are firm and of pleasant taste. They do not become as sweet as naturally ripened fruit, but there is a demand for them. Moreover, the fruit is at maximum fresh weight, which is an advantage to the seller. At destination, brokers are schooled in supplying markets with frequent, small fresh lots of fruit. Each package bears a label indicating that the fruit is perishable and should be refrigerated. Most of the Hayany crop is sold locally in the khalal stage, for many people esteem it as a fresh fruit. Hayany is of little value as a cured date.

DRIP IRRIGATION. Recent papers by Reuveni (12, 13) discuss research on drip irrigation and other aspects of date culture in Israel. Drip irrigation is used in most date palm orchards in the Southern Jordan and Arava Valleys. The systems vary in numbers of emitters/tree, rate of flow and other details. Many different soils are in use, and the trees are of diverse ages and varieties. Temperature and humidity vary markedly throughout the long date-growing area and affect both system layouts and water use.

Drip irrigation is used in only a few orchards in the Jordan and Bet Shean Valleys. The high cost of developing closed water systems in these districts and the presence of algae in open canals, which interferes with filtering, are two of the principal facors delaying the use of drip irrigation.

At the Sheluchot Kibbutz in the Bet Shean district, palms are irrigated with a single line having one dripper in the tree row, with a capacity of 4 liters/hr. These trees are watered daily and the amount given is based on field extension service weekly forecasts of evaporation from a Class A evaporation pan. The irrigation provides the amount of water required for tree use plus a safety margin. Fertilizer, supplied weekly through the irrigation system, consists of 30 liters of liquid ammonia/ha/wk. Additionally, 200 g of a detergent (sodium hexametaphosphate type) are used weekly to clean the lines in 15.6 ha of orchard.

This system fosters excellent growth and yield. At this site, Deglet Noor trees 7 yr old had the appearance and crop of trees 10-12 yr old at Indio, California. At Yotvata near Elat, 3-year-old Deglet Noor trees under drip irrigation were bearing 4-5 bunches each and had the appearance of 5-6 yr old trees at Indio. In correspondence, O. Reuveni states that these trees have 6-8 bunches this year and show no signs of alternate bearing. At Yotvata, established palms under drip irrigation produce 32-34 leaves/yr, whereas in California palms average 24-26 leaves/yr. Mean temperatures at Elat, near Yotvata, are several degrees higher than those at Indio for most months, which may also influence rate of leaf production.

Young trees of Deglet Noor and Medjool, imported from Coachella Valley and planted at Kalia and at Mitzpe-Shalem on the western shore of the Dead Sea, were making good growth under drip irrigation. These sites have deep, rocky soils. Water is applied daily during summer, at 3-day intervals in cooler weather and at about weekly intervals in winter. A double dripper with a discharge rate of 70 liters/hr was in use. The outlet nipple has the inside orifice smaller than the outside one, which fits into the center of a 4-inch long tube. This arrangement of orifices minimizes clogging of the dripper.

About 80% of the Deglet Noor and Medjool trees imported in 1972 from Coachella Valley have survived three growing seasons. The two-year-old Deglet Noors are growing well; Medjool offshoots do not reestablish as well as Deglet Noor offshoots. The slower Medjool growth was thought to be related to fumigation injury. In 1974, some of the Medjool offshoots were fumigated with methyl bromide + 2% chloropicrin; the other offshoots received just methyl bromide. Within 1-2 yr it should be possible to determine whether the different fumigation practices were a factor in Medjool growth.

TABLE 2. Varieties, status and numbers of date palms in Israel, 1975[a]

Variety	Palms (1966-1973)			Distribution		
	Bearing (no.)	Young[b] (no.)	Total (no.)	Bet Shean (no.)	Jordan Valley (no.)	Arava Valley (no.)
Khadrawy	11,399	576	11,975	3,941	3,024	5,010
Hayany	10,350	2,148	12,498	5,263	5,967	1,268
Halawy	4,433	1,478	5,911	2,331	2,782	798
Zahidi	3,948	79	4,027	1,796	1,412	819
Deglet Noor	2,638	1,392	5,030	687	1,086	3,257
Barhee	1,243	621	1,864	547	728	589
Dayri	1,171	400	1,571	271	946	354
Amri	720	622	1,342	173	1,169	....
Medjool	403	2,030	2,433	233	186	2,014
Sphinx	92	35	127	52	23	52
Sayer	264	....	264	....	....	264
Braim	19	....	19	....	19	....
Total females	36,680	10,381	47,061	15,294	17,342	14,725
Total males	1,172	195	1,367	427	453	487

[a]Data extracted from a 1975 publication of Fruit Growers' Organization, obtained through the kindness of O. Reuveni. Original in Hebrew.

[b]Planted 1969-1974.

Drippers are being used successfully to foster rooting of high offshoots. In some cases, the offshoots are enveloped in a plastic bag containing wood shavings; a dripper is arranged to feed slowly into the bag. Within 2 mo, large number of roots are produced; the offshoots can be removed or held in place indefinitely. To reduce costs, tests are underway in which a dripper is placed between the trunk and the offshoot without bagging. It is hoped that sufficient new roots will develop within the fiber around the leaf bases to permit easy establishment of the offshoot when it is detached for planting. The use of drippers is expected to increase substantially the numbers of high offshoots available for propagation of varieties that produce them.

At Sheluchot, tall old trees from which large numbers of offshoots (up to 15) had been cut, required additional support. To achieve this, earth was mounded around each tree to a depth of 1 m or more. A drip line was run over the top of the mound to keep it moist and to foster root development. The trees are now firmly anchored.

In this same orchard, new offshoots have been interplanted between rows and are watered with drippers. The inter-plants are thriving, suggesting that the competition in orchards between inter-plants and old trees may be related to water supply rather than just to light, as has been generally supposed. In California, where flood irrigation is practiced, inter-plants are rarely put in old orchards because they produce thin, poor palms.

FRUIT PROTECTION. Ripening fruit is protected from insect damage by means of fine wire-mesh bags. Placed over the bunches in early khalal, these exclude most of the insects. The bags, made of specially manufactured flexible wire screen, are 1x1 m or 1x1.2 m and cost about $3.00 to $3.50 each. The bags last 8-10 years and do not rust in the interior desert climate. Cheaper bags of plastic mesh have been unsatisfactory because they are subject to severe weathering and to wind and rat damage.

Spraying and dusting have been avoided in order to protect the natural predators of *Parlatoria scale*. This serious date pest cannot be eradicated economically and, at present, biological control operates well.

SKIN SEPARATION. A major problem with Khadrawy date fruit is separation of the skin from the pulp as the fruit softens from khalal to the rutab stage. In some years, skin separation is so severe that not over 10% of fruit is suitable for export.

At Yotvata, studies of skin separation are underway. This year's results indicate that of many materials applied to fruit in the early khalal stage, a few may substantially reduce skin separation. Some of the factors that may influence skin separation in date fruit have been discussed by Gefen and Fahn (5).

FRUITSTALK DISORDERS. Cross-cut, a physiogical-anatomical disorder of date palms, is of such severe occurrence in fruitstalk of 'Sayer' that this variety is being abandoned. The problem of cross-cuts remains serious in Khadrawy, a principal variety. Sometimes half of the fruit stalks (14-16/palm) are so severely notched by the cross-cut lesion that they wither before harvest. This entails heavy loss of crop. No adequate explanation of the cross-cut phenomenon has been proposed since Bliss's (2) work of 30 yr ago. No mitigation of cross-cut damage was obtained by use of gibberellic acid, fungicides, or variations in rate of fertilizer and water applications. Uri Landau, a keen observer, believes that withholding of water from mid-winter until flowering begins may be helpful in reducing the incidence of cross-cuts.

A condition that might be called "heavy stalk" was seen in Khadrawy palms at Moez Haim farm near Bet Shean. The fruit stalk is unusually thick and dies before harvest, ruining the fruit.

Sunburning of Khadrawy fruit stalks is being studied. The application of whitewash to the upper surface of the leaf stalk, as practiced in Indio, seems to be helpful.

DIPLODIA CONTROL. The fungus *Diplodia phoenicis* is the cause of a leaf dieback of pruned leaves of transplanted palms, although it is of negligible importance on leaves of established palms. A spray or slurry of benomyl gives good control. If leaves are cut back some weeks before the palm offshoot is cut from the mother tree or transplanted from the nursery, Diplodia attacks are minimal.

POTASSIUM TO OFFSET NEMATODE DAMAGE. Marked improvement in palm growth has been obtained in orchards with a severe root-knot nematode infestation by application of K_2SO_4 and KCL at rates up to 10 kg/tree/yr. The incidence of nematodes is not affected, but tree growth is stimulated. This suggests that K is a critical nutrient for the palm or the nematode, or both, and that supplementary amounts offset the nematode damage.

LADDER RIG. At Kibbutz Sheluchot, Uri Landau has developed a novel lightweight rig for carrying a 12.2 m (40 ft.) aluminum extension ladder. A light pipe frame in a truncated triangular form, 3x3x3 m, and two 75 cm diam. small-rimmed wheels at the wide end, forms the base. At the truncated apex, a 3-m-high inclined A-frame holds the ladder, the legs of which rest on the ground when the rig is stationary. On fairly smooth ground the ladder and rig are easily moved. This is a good labor-saving device. Details of the equipment have been given to the ARS agricultural engineers.

MAN-POSITIONING EQUIPMENT. A small, versatile man-positioner was observed at Neot Hakkikar. This three-wheeled machine is gasoline-powered and is operated from a central control panel or from a "squirrel cage" on a mechanical lift that can position a man up to 5 m in a palm for many types of work: pollination, tying down, harvesting, pruning and pest control. On smooth ground, the rig can be operated with the cage at any height and at any angle. The machine can provide compressed air for use with pneumatic tools. Pneumatic shears of special construction permit rapid leaf and offshoot pruning by a skilled operator. The cost as of October 1974 was estimated at $3,000.

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PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN

I traveled to the People's Democratic Republic of Yemen (PDRY) in January 1975 to estimate the feasibility of modernizing date culture in the Wadi Hadramaut, a principal agricultural area. This was done in response to a request to the Agricultural Research Service by the International Bank for Reconstruction and Development (World Bank). This study of date palm culture supplemented the work of a World Bank Appraisal Mission, which consisted of an engineer, an economist, and an agronomist. S. H. Sakkaf, Assistant Horticultural Officer at Seyun, accompanied me in the Wadi Hadramaut and provided much of the information reported here. Two restricted FAO reports by W. H. Barreveld, 1974, and by Hisham El Akhrass, 1972, on date production in the Hadramaut were very useful in this work. Comprehensive inter-agency studies by FAO for the World Bank cover nearly every facet of agriculture in the proposed project area except date culture. I am not aware of any generally available reports on date culture in PDRY, outside of brief remarks by travelers, especially Van der Meulen and Von Wissman (14), and a report on date varieties (4).

This brief sketch of date culture is based on less than four working days in the project area, which comprises some 7,000 ha of cultivated land distributed irregularly along a distance of more than 100 km and varying from less than 2 km to a few km in width. The elevations vary from 360-600 m, and the valley lies at about 17° N lat. Date culture in the Hadramaut is performed in a traditional manner with many of the same techniques used in other Old World date-growing areas. Mechanical cultivation, where practiced, is primarily for the benefit of the intercrops, not the date palms.

VARIETIES AND PRODUCTION. In Table 3, Barreveld's and El Akhrass' information on date varieties has been incorporated with notes given by Sakkaf. Varieties established at Redud State Farms, in a modern 8x8 m planting, are identified by footnote *b*. Chemical and physical data on five Yemeni date varieties are given by Crowther and Smith (4).

Hamrah, the most widely grown variety, has been estimated to represent 70% of the total crop. Recent plantings of Madini, a small-fruited, choice variety, have increased at the expense of other varieties. Bedouins are reported to prefer Hashidi, Argadi, and the Asfar mixture of yellow-brown fruited varieties. Gizaz and Migraf are reportedly good varieties for coastal plantings, especially in the area just west of Mukalla.

Date production in the Hadramaut is estimated to be about 20,000 metric tons annually. Most of the fruit is consumed locally by farmers, townspeople, and nomads. Something less than 500 tons are shipped to the coast, principally to Aden. Export

TABLE 3. Summary of date varieties in Wadi Hadramaut, after Barreveld, El-Ahkrass, and Sakkaf

Variety	Color	Bunch weight (kg)	Bunches palm (no.)	Av. fruit weight (g)	Seed weight (%)[a]	Remarks
Abdul Rahman[b]		....	....	....	....	Undescribed variety, Redud State Farm
Argadi	Light brown	5	7	8.3	8.7	Very good quality; tendency to skin separation
Azar (Izar)[c]	Light brown to brown	5	8	....	....	Good quality; tendency to skin separation
Gizaz[b] (Jizaz)	Light brown to brown	7	7	8.4	13.0	Very good quality; tendency to skin separation
Hajri		5	7	....	....	....
Hamrah[b]	Brown	9	6	6.5	11.4	Most common date variety
Hashidi	Dark	7	8	....	....	Good quality, from Sah district
Madini[b]	Dark brown to blackish	6	6	4.5	15.0	Esteemed for its taste; small
Migraf[b] (Mijraf)	Brown	8	7	8.5	11.6	Flesh transparent, somewhat soft
Mashari	Dark	....	....	....	....	
Sabyat-chok[b]		....	....	....	....	
Sabyat-maimum[b]		....	....	....	....	
Sarayha[b] (Suryea)[d]	Purple brown[d] Dark	....	....	7.0[d]	13.6[d]	
Scotra	Dark	....	....	....	....	
Yahmi[b]	Dark	....	....	....	....	
Yahtimah[b]		....	....	....	....	

Asfar, a mixture of yellow varieties.
Subaiy, a mixture of brown varieties

[a]Percentage of whole fruit weight.

[b]Varieties included in Redud State Farm planting.

[c]Barreveld's spelling. Sakkaf's spellings are given preference because of his intimate local knowledge of the varieties.

[d]Crowther and Smith (4).

of dates to European markets has not been exploited (4). The unfumigated dates are packed in fiber baskets and compressed to the point where the fruit often bursts and syrup runs out of the containers. Quality is fair to poor. The controlled price of $0.26 /kg did not provide a satisfactory return to the growers, who were paid about $0.13 /kg for the 1974 crop.

The wholesale buyer takes considerable risk, because he reportedly has little or no choice as to which lots of dates he receives through the Marketing Authority's agents. Some dates are sold at prices higher than the official rate. Several thousand tons of dates are imported annually, especially from Iraq; Zahidi seems to be the principal variety imported.

SOIL. Date palms in the Wadi Hadramaut are grown on soils that vary in composition from silty clays to light sandy loams with low silt content. At Sah, the soil is mostly a heavy silty clay. At Tarim, the soil also appears to be heavy, though sandier than at Sah. In the Seyum-Shiban area, the soils vary from fairly heavy to medium sandy loams; farther west at Qatn, the soils are conspicuously sandier. Where I saw cuts in stream beds, the soil was deep. At the entrances to well shafts, the soil was deep and palm roots were conspicuous several feet down in the profile. Drainage is reported to be good in most date palm areas. Salinity is a problem on some soils.

WATER. Irrigation water is supplied to date palms as: 1) ground water from relatively shallow wells, often less than 16 m deep; 2) as spate (flood) irrigation involving water gathered and distributed during storms; most agricultural areas receive at least 1 spate irrigation annually, although more than 12 mo may pass without rain; 3) as a combination of well and spate, exemplified by Sah where irrigation consists of two good well water irrigations and usually 1 good flood annually; 4) and as gravity flow irrigation from a river which flows permanently for a distance of about 15 km in the Sah district.

Ground-water irrigation is achieved principally from tube wells equipped with diesel pumps. The water is distributed in a system of unlined, gravity-flow main and secondary channels. Main channels are about 60x30 cm and lateral or secondary channels vary in size down to 20x10 cm. The channels are carefully conducted throughout the fields; siphons are provided to underpass roads and trails. Channels are usually from 0.3-1 m above ground level, but channels 1.5-2.5 m above field level were observed. Channels are lined with clay and are kept clean and repaired by hand, a job done by children as well as by irrigators. Water is led into basins and to individual palms, or group of palms, as required.

Flood irrigation is managed through a series of gravity-flow channels that originate upstream from the orchards. One or more main channels feed into the basins, which are provided with dikes or walls 0.6-1.5 m high. Water is trapped in the basins and allowed to infiltrate; on heavy soils water may stand more than 1 mo. The infiltration rate increases as soil texture becomes sandier until, in the sandiest places, water may infiltrate in 1 to a few days.

FERTILIZER. Currently, fertilizer is not applied to date palms. Animal and human manures are used on intercrops, especially vegetables, and adjacent palms may receive some benefit. At Sah, the reported use of manure was 68 kg/58 m^2, which translates into 176 kg N/ha, if a N content of 1.5% is assumed. This is probably a high estimate.

TREE CENSUS, AGE, AND CONDITION. Tree age is highly variable and represents the whole range from young offshoots to trees that must be well over 70 yr old. Some trees are reported to be 120 yr old. The current census, estimated in unpublished reports, of 500,000 trees under well-irrigation and 300,000 trees under spate irrigation, is probably low. Exclusive of the area reserved for offshoot production, Sakkaf estimates total palms at close to 1,500,000; I tend to agree with him on the basis of brief observations. A real census is needed. For purposes of the project appraisal, I used the current figures of 500,000 and 300,000, respectively, in making estimates. The remaining trees, up to perhaps 700,000, are considered marginal to poor. In the project area, exclusive of the spate-irrigated and poorly managed well-irrigated areas, approximately 50% of the palms appear to be in good to excellent condition with leaves of good size, color and longevity. Another 35% are fair to good and could be improved with adequate irrigation. About 15% should be culled because of poor condition, age, or crowding.

Many non-bearing trees are essentially good trees, but lack sufficient care to bear annual crops. Trees may remain fruitless for more than one year when deprived of fertilizer and water.

Leaves are retained for at least 3-4 yr and the palms comonly bear around 100 leaves. Some excellent trees bear up to 125 or more leaves and have the inherent capacity for heavy bearing. Flowering is good, but trees in the project area seldom bear more than 10 bunches and usually fewer. Obviously, some trees bear well and raise the average yield.

TREE SPACING, PLANTING ARRANGEMENTS. Regularly spaced palms were found only on the experimental farm and in a few well-irrigated, small areas, such as a planting at Sah of Gizaz palms, about 8x8 m on the square. Perhaps 10% of the palms occur as single, spaced stems irregularly distributed and frequently not more than 5-7 m apart. El-Akhrass' estimate of 25% of single palms seems too high from my observations and from discussion with Sakkaf. The remainder of the palms occur as groups of 2-10 or more stems and probably originate from a single parent plant. One cannot rule out the possibility that, in clumps of widely diverse ages, some of the trees may be seedlings. Groups of trees frequently have too many stems and are irregularly spaced. The outer trees probably get enough light, but the center ones are heavily shaded. Except for some very dense plantings, tree density is in the range of 6x6 m (278 trees/ha) to a 7x7 m (204 trees/ha) spacing in much of the project area.

In the Qatn district, palms are planted along the main irrigation channels that parallel cultivated fields. The narrow plantings are too dense, but density is partially compensated by full illumination along the open sides of the row. Most of these long rows run in a north-south direction. The palms serve as excellent windbreaks and their roots bind the channel banks. Some of the most beautiful palms in the Wadi Hadramaut were in these rows.

Trees of all ages, but especially those up to 10 yr of age, bear too many offshoots. which depress growth and yield of the parent palm. Tree growth is rapid in the Hadramaut. Transplanted offshoots may begin flowering in 2-3 yr and are said to reach full-bearing, under current cultural conditions, in 7-10 yr.

OFFSHOOT MANAGEMENT. A large proportion of the offshoots is produced under spate or well irrigation in what appear at first sight to be areas of scrubby abandoned palms, of no use except for erosion control, fuel and fiber. These areas are estimated by Sakkaf to comprise more than 200 ha and are located mostly in the Seyun-Shibam district. However, these scrubby palms, often with large numbers of offshoots, are of known varieties. Identification and cutting of offshoots in these areas is done by skilled persons who can identify the varieties in spite of severely restricted growth and modified plant characters. These nurseries supply plants for export, several thousand of which have been sent to the coast and to Kenya and Somalia.

Offshoots are planted directly in the field and survival is reported to be good. Offshoots are watered frequently for 2-3 yr until well established. The Redud Farm planting was made from such offshoots. At 4 yr of age, they are vigorous and nearly all are flowering. The use of offshoots from stressed palms is of special interest, because it confirms observations on offshoot performance by Nixon (8) in Sudan. It is apparently common knowledge in Old World date culture that offshoots transplanted from palms under some stress for water root more quickly than offshoots from lush trees.

Current prices for offshoots at Seyum ranged from $0.25-$0.50 for common varieties to about $3.00 for choice and scarce varieties.

LEAF REMOVAL AND DETHORNING. Old leaves are removed after harvest; this operation is often combined with the first round of pollination. Some pollinators were observed pushing dead leaves loose with their feet. Good trees are usually neatly trimmed. The lower leaves are dethorned at the time of pollination to permit safe access to flowers and fruit.

POLLINATION AND BUNCH MANAGEMENT. Pollination is done by individual growers or members of cooperatives. Female spathes are opened at the proper time and pollen from sprigs of male flowers is dusted over the females. The male flowers are not tied into the spadix, but are used until their pollen is gone, on several females. Pollination is made on new inflorescences as they emerge throughout the flowering season, which begins in mid-December and continues until at least March.

At Sah and Tarim a unique practice is used. Immediately after pollination, the pollinator paints the entire spadix with crude castor oil, prepared locally by water extraction. Without the oil, growers claim that flower and young fruit shatter are excessive. One should determine what is operating here — whether a growth regulator effect, protection from drying, insect control or repellence, or an erroneous impression. The last possibility is countered somewhat by the reinstatement of the practice at Tarim, where poor fruit set followed abandonment of the oil treatment.

When the bunches are about 2 mo old, up to 10 of the best are left; the rest are removed. At that time, each bunch is arranged over one or two leaf rachises to support it, or the bunch is pulled sideways and over leaf bases close to the trunk. Ordinarily, the bunches are not tied. No bunch thinning is practiced. Mat baskets woven from leaves of a local dwarf fan palm are wrapped around each bunch of fruit some 2 mo before harvest.

HARVEST. Dates are sorted into two or three grades, but I was unable to determine the quality in each. I would expect the grades to be quite variable. Fruit obviously damaged by birds, insects, or fungi, as well as shrivelled or unpollinated fruits, are reportedly culled for livestock feed, but a substantial amount of incipient insect damage must escape detection and contribute to deterioriation of stored date products. This problem is discussed under *Insects*.

INTERCROPS. Dates are intercropped with grain, forage, and vegetables. The date palms receive water and fertilizer in accordance with the needs of the intercrops, although supplementary water may be supplied to palms during fallow periods. Consequently, dates seldom receive primary attention and, while they may appear healthy, may not have enough water and fertilizer to produce either annual crops or optimum yields in the year of bearing.

DISEASES. Palms in the project area are remarkably free of obvious diseases. Leaf spotting caused by age, salt, drought, or mechanical injury is negligible. As in other date-growing areas, rain during the ripening and harvest period could lead to fungal spoilage in fruit. Although no ripening fruit was seen, reports suggest that souring, probably duc to yeasts and other fungi, occurs in association with insect infestation.

INSECTS. Insects attacking the tree are not of much importance. Parlatoria scale (*P. blanchardi Targ.*) is widespread, but of low incidence and negligible importance. Injury to leaves and young fruits, probably caused by the Old World date bug (*Omatissus binotatus lybicus* de Berg.) was noted at Sah, and was of minor occurrence. This insect may attack young fruits. A palm stem borer, *Orcytes* sp., attacks trees at Seyun, but the amount of damage is small.

A curious type of loose ant nest was found in palms in Seyun. The nests were built among the spike leaves by large black ants 1.5 cm long. Since no other insect was seen and no honeydew was present, this is probably not an association of ants and some insects useful to them. Minor termite damage to leaves was seen and some trunk damage was reported. Mites are reported to occur in date palms, but the species is not known and damage is apparently minor.

Reports of shattering in young green fruit indicate that insects may be involved early in the season. The use of castor oil in pollinating operations suggests an empirical control method for insects. Infestation of ripening fruit is obviously a serious problem (Table 4). El-Akhrass' estimate of 30-40% damage is probably conservative. Personnel of the Marketing Authority confirmed that insect infestation is of major concern in stored dates and those offered for sale, and that insect infestation must be eliminated if quality dates are to be marketed. If the women and children sort out visibly infested fruit before packing, substantial insect infestation in stored fruit indicates a) heavy initial infestation and b) post-harvest development of larvae and adults in unfumigated, stored fruit. The species of infesting insects are unknown, but the larvae indicate that one or more of the ubiquituous species of *Cadra* are involved. No nitidulid beetles were seen or reported.

TABLE 4. Insect infestation in samples of stored dates

Source	Variety and condition	Infestation[a] (%)
Sah, private storage	Gizaz, fruit entire	16
	Unknown, fruit crushed	33
Seyun, commercial storage	Hamrah, entire fruit	48
	Madini, fruit crushed	12
	Migraf, pitted	0

[a]All infested samples had conspicuous insect frass and feeding marks, and had one or more live larvae.

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CHANGES IN QUALITY OF FIELD RUN DEGLET NOOR DATES STORED OUTDOORS AND UNDER REFRIGERATION: A PROGRESS REPORT

S. M. NORMAN, L. G. HOUCK, D. C. FOUSE, AND J. W. SNIDER

Food Technologist, Plant Physiologist, Biologican Technician, and Biological Laboratory Technician, respectively, Market Quality Research, Agricultural Research Service, U. S. Department of Agriculture, P. O. Box 112, Riverside, California 92502.

ABSTRACT

This report covers the first 5 mo of a 12 mo study on changes in the quality of 'Deglet Noor' dates stored outdoors and under refrigeration. From November to April only small changes in fruit quality were found among dates kept in either storage regime. Differences between dates in unlined and polyethylene-lined bins were small. The moisture content of dates became more uniform as the storage season progressed, with a decreased percentage of dry or very moist fruit and an increased percentage in natural, waxy, and No. 1 dates. Sugar content of fruit remained fairly constant, but pigment content increased. Changes in the shear force required to cut dates were inconsistent.

Date Growers' Inst. Rep. 52:25

INTRODUCTION

Changes in quality of dates during storage have been studied (9, 10, 11, 12, 13). Because of mechanical harvesting and fewer picks per season, more dates of different stages of maturity and dryness reach the packinghouse now than previously (6). Because of these changes, the effects of storage conditions on quality of dates should be determined and optimum storage conditions should be defined.

In commercial practice, dates are stored outdoors in stacks of bins covered with black polyethylene film and later moved to refrigerated storage. Cold storage temperatures in commercial facilities range from below zero to 7° C. Occasionally bins of dates are put directly into refrigerated storage.

Two 12-mo tests were started to study the effects of storage conditions on quality of Deglet Noor dates. The purpose of the first test was to study changes in date quality under actual commercial conditions of refrigerated storage and a combination of outdoor and refrigerated storage. The second test was designed to compare the quality of three storage grades of dates held under refrigeration in polyethylene-lined and standard open bins. These tests are a cooperative project between the Cal Date Company, Market Quality Research and Agricultural Engineering Research units of the U. S. Department of Agriculture, and the University of California, Riverside.

MATERIALS AND METHODS

STORAGE TEST NO. 1. 'Deglet Noor' dates were harvested about November 1, and December 1, 1974, and January 1, 1975 from three different date gardens near Indio, California. The three harvests are designated early-, mid., and late-season, respectively. Bins (approximately 800 lb fruit/bin) of dates, 18 from each harvest, were stored outdoors for 0-5 mo with subsequent cold storage for 7-12 mo at —3° C, 2° C, and 4° C. Initially, one bin from each harvest was put in each of the three refrigerated storage rooms, and the remaining 17 bins from each harvest were stored outdoors. Then, each month one bin from each harvest was transferred from outdoor storage to each of the three refrigerated rooms until all 54 bins were in cold storage. At first, all bins were sampled each month with a standard bin sampler used for incoming fruit at the packinghouse. After 5 mo, all bins were sampled by hand either because partially empty bins did not dump adequately in the bin sampler or the dates were too sticky to fall freely from the bins. USDA graders measured the moisture content of the fruit and graded a 50-oz (1,417 g)[1] sample from each bin. Waxy, No. 1 dry, and No. 2 dry dates from each graded sample were then analyzed at the USDA Market Quality Research Laboratory in Riverside for moisture, sugar, and pigment content at harvest, when a bin was moved from outdoor to refrigerated storage, after 5 months cold storage, and will be analyzed at the end of the 12 mo test. Textural quality was evaluated each month.

STORAGE TEST NO. 2. Three storage grades, waxy (mostly natural and waxy fruit), No. 1 dry (mostly waxy and No. 1 dry fruit), and No. 2 dry (mostly No. 1 and No. 2 dry fruit), were washed and separated from the dates harvested in December. These three grades are hereafter called grades A, B, and C, respectively. Dates of each grade, in conventional open bins and bins lined with polyethylene film, were stored in the same three refrigerated storage rooms used in Test No. 1. Sampling and grading were the same as in Test No. 1. Each month natural and waxy dates from grade A, No. 1 dry dates from grade B, and No. 1 and No. 2 dry dates from grade C were analyzed from each 50-oz graded sample for moisture, sugar, and pigment content and evaluated for textural quality.

STORAGE TEMPERATURE. The temperatures of outdoor air and of dates inside representative bins held both outdoors and under refrigeration were monitored with Ryan 30-day recording thermographs.

[1] The 50-oz sample is a standard measure used in grading dates and the measure is retained in the text

USDA GRADING. Experienced USDA graders rated 50-oz samples of dates from each bin according to current commercial standards. Before grading, the number of dates/kg was determined and a composite moisture measurement was made on a 283 g ground sample of pitted dates with a dried fruit moisture tester. The grades in percent by weight were then determined as follows: grade B (included green, moist, natural, waxy, and No. 1 dry grades); grade C (included soft, medium, and No. 2 dry grades); and culls (included dates which were high in moisture, dirty, moldy, unpollinated, infested, shriveled, or small).

MOISTURE DETERMINATION. Two methods, vacuum-oven drying and near-infrared (NIR) absorption (3,4), were used for moisture determinations of graded dates at the Market Quality Research Laboratory in Riverside. Dates (20-25) were pitted and cut lengthwise. Two samples were made from a half of each of the 25 dates. In the vacuum method one sample of halves was dried under vacuum (100 mm Hg) at 65° C for 72 hr. For occasional samples, which contained less than 20 dates, we used the NIR method; dates were disintegrated in an equal weight of anhydrous methanol with a Brinkmann Model PT-45/2 Polytron. Sub-samples were diluted with anhydrous methanol and the absorption of the water in the methanol was measured at 1940 nm on a Beckmann Model M IV spectrophotometer.

SUGAR DETERMINATION. The remaining sample of halves was disintegrated in an equal weight of 80% ethanol with the Brinkmann Polytron. Duplicate subsamples of the disintegrated date-ethanol samples or of date-methanol samples from the NIR moisture method were boiled with 80% ethanol for 1 hr to extract the sugars. The alcohol extracts were filtered, made to a known volume, and aliquots evaporated to dryness under a stream of nitrogen. Sucrose and the oximes of fructose and glucose were silylated with N-trimethylsilylimidazole (TMSI) by the method of Pierce (7). The amount of TMSI-sugar-oxime derivatives was measured with a Varian Model 2800 gas chromatograph equipped with dual hydrogen flame detectors and 182.9x0.3 cm (6'x⅛") stainless steel columns packed with 3% OV-17 on Chromosorb WHP 80/100 mesh. The columns were temperature programmed from 170 to 270° C as follows: isothermal at 170° for 2 min, up 2°/min for 2 min, up 10°/min for 4 min, up 14 min/4 min, and isothermal at 270° for 2 min. Gas flows were: nitrogen, 40cc/min, hydrogen, 30 cc/min, and air, 400 cc/min.

PIGMENT DETERMINATION. Soluble pigment content was estimated by measuring

the absorption of the 80% ethanol-sugar solutions at 400 nm on a Beckmann Model M IV spectrophotometer. We converted the absorbance reading to mg/g dry wt by using the extinction coefficient of 0.650 cc/(mg) (cm) given by Maier and Schiller (10) for date pigment. Maier and Schiller recommended extraction of the date tissue with cold 65% methanol. The spectra were the same whether dates were boiled in 65% methanol or 80% ethanol. Average pigment content (mg/g) for the same ten samples was 9.45 with 65% methanol and 9.57 with 80% ethanol.

TEXTURAL QUALITY[2]. The force required to cut a pitted date lengthwise was measured with an Allo-Kramer Shear Press Model S-2H equiped with a shear cell containing one blade which meshed with a groove in the base of the cell assembly. During the first 3 mo we used a 2,500 lb (1,134 kg) proving ring, and thereafter, a 250 lb (113 kg) proving ring. Ten pitted dates were individually cut lengthwise in the shear cell and the peak shear forces were averaged to give an average shear-force value in lb/date.

RESULTS AND DISCUSSION

STORAGE TEST NO. 1

STORAGE TEMPERATURE. Outdoor air temperature ranged from 6-28° C in November, 0-21° C in December, 2-27° C in January, 2-28° C in February, 9-22° C in March, and 7-30° C in April. The temperatures of dates in the three cold storage rooms was —4-0, mean —3° C; 0.5-3, mean 2° C; and 3-9, mean 4° C.

USDA GRADING. At harvest, early- and mid-season dates were primarily No. 1 dry and No. 2 dry fruit (Fig. 1). The early-season dates were predominantly small and would normally be graded as culls, but for this test size was disregarded and small dates were graded. Late-season fruit were mostly natural, waxy, and No. 1 dry fruit. Part of the diversity of grades between harvests was attributed to variability in quality and production of each garden. During storage of 5 mo outdoors or under refrigeration, early-season dates decreased sligthly in No. 2 dry and increased in No. 1 dry fruit; mid-season dates increased in waxy, natural, and No. 1 dry, and decreased in No. 2 dry fruit. During storage late-season dates increased in waxy and natural and decreased slightly in No. 1 dry fruit. In all harvests green and moist dates were converted to other grades during storage.

[2] Shear press data are given in the avoirdupois weight system.

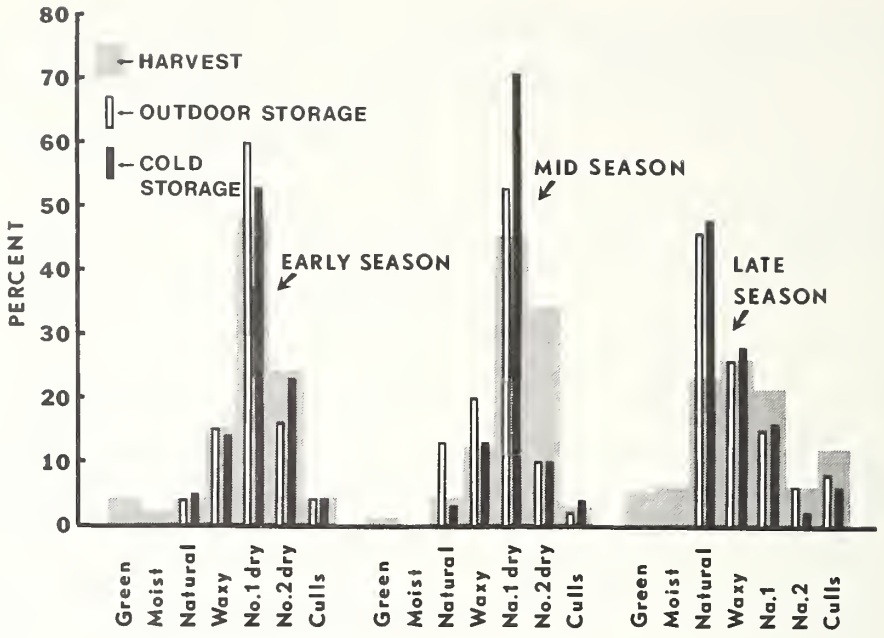

FIG. 1. Grades determined by USDA graders at harvest, after outdoor storage, and after cold storage at —3° C. Early- and mid-season dates were stored 5 mo and late-season dates were stored 4 mo.

MOISTURE CONTENT. During storage, the moisture content increased in all grades except waxy mid-season dates (Fig. 2). Early- and mid-season waxy dates had higher moisture contents before and after storage than No. 2 dry dates. For months 1 and 2, samples were taken during rainy weather which explains their high moisture contents.

In late-season dates the moisture contents of composite, waxy, No. 1 dry, and No. 2 dry dates were 17.8, 16.5 14.4 and 14.5% before storage and increased to 18.3, 17.7, 16.7 and 16.8% after 3 mo, respectively.

The increase in moisture content of the three grades during storage of all harvests correlated with the change in grades during storage (Fig. 1), since the No. 2 dry fruit, green, and moist fruit generally decreased and the natural, waxy, and No. 1 dry fruit (except for No. 1 dry dates from late season) remained about the same or increased during storage.

PIGMENT CONTENT. Pigment content increased in all grades of dates from all harvests during 5 mo of outdoor storage

TABLE 1. Sugar content as percent dry wt[1] of waxy, No. 1 dry and No. 2 dry dates from early-, mid-, and late-season field run dates[2] stored outdoors, 5, 4 and 3 mo, respectively

Season	Months Stored	WAXY			NO. 1 DRY			NO. 2 DRY		
		Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose
		%		%	%	%	%	%	%	%
EARLY	1	11.0±0.8	11.3±0.9	56±4	10.6±0.9	11.6±1.0	58±3	10.3±1.2	11.0±1.1	58±4
	2	11.7±0.8	12.3±0.4	59±5	11.9±0.5	12.5±0.6	58±2	11.3±1.1	11.7±1.5	57±3
	3	13.0±0.2	12.7±0.2	63±3	12.6±0.2	12.7±0.7	61±3	11.3±0.6	10.9±0.7	66±2
	4	12.1±1.7	12.6±2.0	53±3	11.2±2.2	11.1±2.7	54±2	10.6±1.8	11.0±2.2	55±4
	5	12.5±0.9	12.7±1.1	53±3	11.6±0.8	11.8±0.7	57±2	9.4±1.3	9.8±1.3	55±4
MID	0	10.1±0.7	10.6±0.6	57±3	10.2±0.4	10.7±0.4	54±2	9.5±1.0	10.1±1.0	58±3
	1	10.7±0.8	11.1±0.8	61±2	10.5±0.4	10.8±0.3	59±1	8.5±0.4	9.1±0.4	62±1
	2	13.2±2.2	13.0±2.1	60±2	12.7±2.2	12.5±2.3	61±5	11.2±0.6	11.4±0.4	61±2
	3	10.3±1.1	10.7±1.3	57±1	9.9±0.6	10.5±0.5	57±3	8.5±0.5	9.1±0.4	60±1
	4	12.8±1.4	13.2±1.1	53±10	11.3±0.8	11.5±0.7	59±2	8.8±1.0	9.1±0.9	62±2
LATE	0	12.3±0.6	12.5±1.0	62±2	12.7±1.7	12.7±1.8	55±5	10.7±1.7	10.8±1.4	59±5
	1	14.0±1.4	14.6±1.2	52±2	14.7±1.6	15.3±1.6	54±5	11.4±1.7	12.1±1.5	59±8
	2	14.4±1.2	14.6±1.0	55±2	13.9±2.4	13.9±2.0	55±2	10.6±1.8	11.2±1.7	62±2
	3	13.5±1.2	13.8±1.2	53±2	12.9±3.2	13.1±3.1	56±7	11.2±3.5	11.7±3.5	57±9

[1]Each value represents the average ± the standard deviation of duplicate determinations of samples of three bins.

[2]Early-, mid-, and late-season dates were harvested about Nov. 1 and Dec. 1, 1974, and Jan. 1, 1975, respectively.

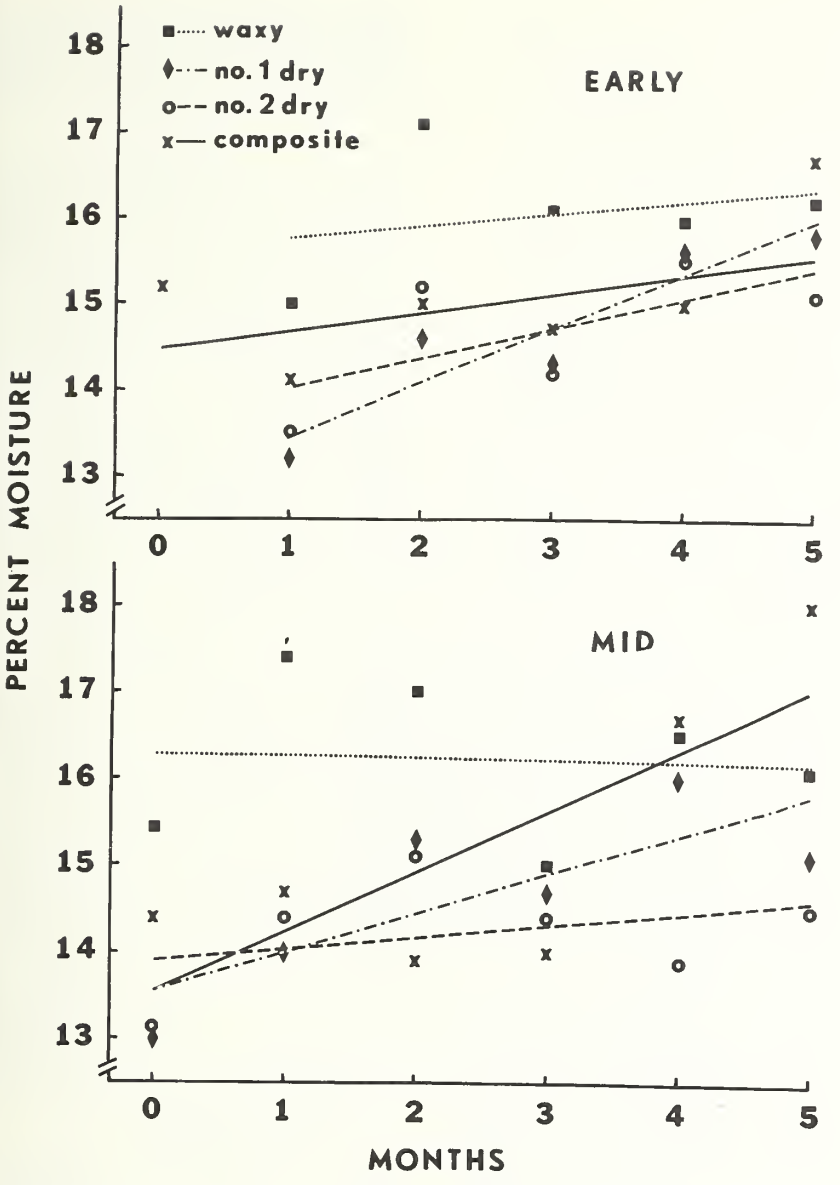

FIG. 2. Moisture content of the composite and waxy, No. 1 dry, and No. 2 dry dates of early- and mid-season fruit held 5 mo outdoors.

(Fig. 3). Pigment extraction measures the amount of soluble pigment and indicates the darkening associated with storage, even though it is not directly related to the darkness of the dates that was observed visually. After storage, natural dates which were not measured for soluble pigment, were visibly darker than waxy. After 5 mo, waxy were visibly darker and No. 2 dry lighter than No. 1 dry dates.

SUGAR CONTENT. Fructose, glucose, and sucrose contents of dates of all grades from all harvests held outdoors for 3-5 mo (Table 1) agree with published data (1,11,12). Sugars were not determined at harvest for the early-season dates, but after 1 mo the ratio of sucrose to fructose plus glucose was 2.5-2.7. Generally, sugars were higher in late- than in mid- and early-season dates. Waxy contained slightly more and No. 2 dry slightly less fructose and glucose than No. 1 dry dates, although total sugar content was about equal in all grades. Slight inversion during storage was apparent in waxy fruit as shown by the ratio of sucrose to fructose plus glucose; this ratio decreased in waxy fruit from 2.5 to 2.1, 2.8 to 2.0, and 2.5 to 1.9 for early-, mid., and late-season fruit, respectively. For No. 1 and No. 2 dry fruit the ratio of sucrose to fructose plus glucose was somewhat erratic during storage.

TEXTURAL CHANGES. The shear press subjected dates to a combination of compression and shear forces to cut through each date. In this paper, these peak cutting forces will be called "shear force" and expressed at lb/date. Peak shear-force values (Fig. 4) represent the average of 18 bins for 0 mo, 15 bins for 1 mo, 12 bins for 2 mo, 9 bins for 3 mo, 6 bins for 4 mo, and 3 bins for 5 mo. The change from a 2,500 lb proving ring (shaded area of Fig. 4) to a 250 lb ring was necessary because the cutting resistance of the dates did not increase as anticipated and the shear force became too low to measure with the larger ring. Shear force decreased with storage except for the late-season dates which remained fairly constant the last 2 mo. Generally, waxy dates required the least and No. 2 dry the most cutting force throughout storage. Fruit to fruit variation shown by standard deviations was greatest at harvest (waxy, ± 8; No. 1 dry, ± 10; and No. 2 dry, ± 15 lb); and decreased during storage (at 4 mo: waxy and No. 1 dry, ± 7 and No. 2 dry, ± 9 lb). As storage progressed, No. 2 dry dates became brittle and some were not cut, but split apart and gave low values which incorrectly indicated decreased cutting resistance.

STORAGE TEST NO. 2

SAMPLING. Apparently sugars, leached from the dates by the wash water, accumulated and concentrated on the dates, as the free water evaporated or was absorbed during storage, and stuck the dates together. The dates became very difficult to sample after 2 or 3 mo.

USDA GRADING. Differences in grades were small for the three storage temperatures so the data were combined (Fig. 5). Each storage grade contained different proportions of the USDA grades. After 5 mo for grades A and B, green, moist, and No. 2 dry fruit were converted to other grades, No. 1 dry fruit decreased and waxy and natural fruit generally increased. In grade C No. 2 dry dates decreased, waxy dates

TABLE 2. Moisture content as percent[1] of composites and natural, waxy, No. 1 dry, and No. 2 dry dates from three storage grades of dates before and after 4 mo in cold storage at —3 to 4° C in unlined and polyethylene-lined bins.

Storage grade	USDA grade	At harvest	After storage 4 mo	
			Unlined bins	Lined bins
		%	%	%
"A"	Composite	20.8±1.4	19.0±2.2	17.0±0.5
	Natural	21.8±1.1	18.9±1.9	18.1±1.6
	Waxy	20.2±0.9	18.2±1.2	17.4±1.1
"B"	Composite	18.8±1.6	17.8±0.6	18.5±1.0
	No. 1 dry	15.7±4.7	17.8±0.4	17.7±0.6
"C"	Composite	16.5±1.1	15.5±1.3	16.3±0.6
	No. 1 dry	17.1±0.5	16.6±0.3	16.4±0.8
	No. 2 dry	15.2±0.7	15.8±0.0	15.4±0.6

[1]Values represent the average ± the standard deviation of 6 bins at harvest and 3 bins after storage.

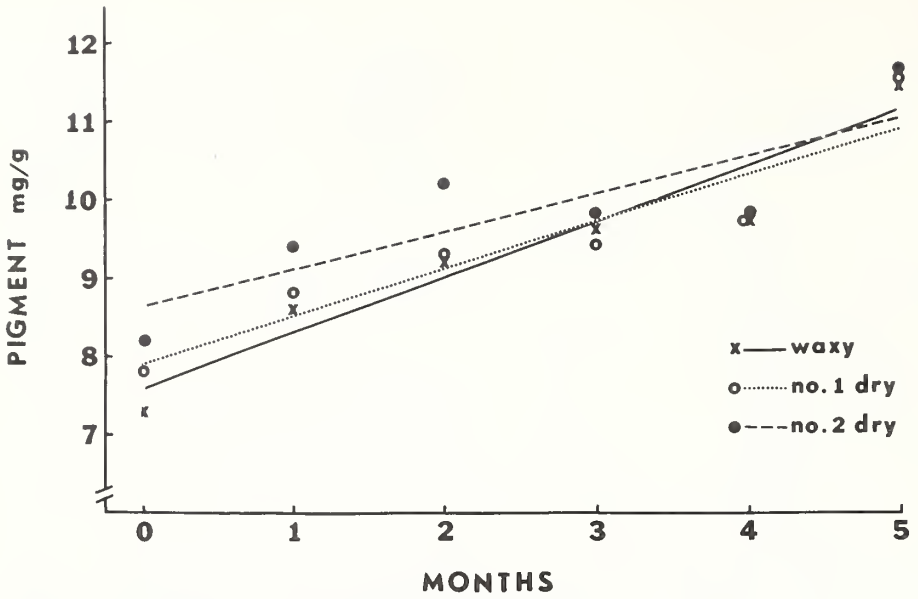

FIG. 3. Pigment content of waxy, No. 1 dry, and No. 2 dry dates from early-. mid-, and late-season field run fruit after 5 mo storage outdoors.

increased, and No. 1 dry and natural dates remained about the same. Consistent trends in grade change could not be established between unlined and lined bins.

MOISTURE CONTENT. During storage, moisture content decreased in grade A, decreased slightly in the composite and increased in No. 1 dry dates in grade B, and decreased slightly in the composite and No. 1 dry and increased slightly in No. 2 dry dates in grade C (Table 2). The differences in moisture content between unlined and lined bins were slight and inconsistent.

PIGMENT CONTENT. Pigment contents of natural and waxy dates from grade A were, respectively, 6.2 and 5.9 mg/g before storage and 8.4 and 8.6 mg/g in unlined bins and 8.9 and 9.0 mg/g in lined bins after 4 mo in cold storage. Pigment contents of No. 1 dry dates from grade B were 7.1 mg/g before storage, and 9.1 in unlined bins and 8.2 mg/g in lined bins after 4 mo. Pigment contents of No. 1 and No. 2 dry dates from grade C were, respectively, 7.2 and 5.0 mg/g before storage and 9.2 and 9.4 in unlined bins and 8.3 and 9.0 mg/g in lined bins after 4 mo in cold storage. Pigment content increased 2-4 mg/g with storage. The difference in pigment content between dates in unlined and lined bins was less than 1 mg/g. Visible darkening during storage was not obvious.

SUGAR CONTENT. No. 1 and No. 2 dry dates were lower in fructose and glucose and higher in sucrose than the natural and waxy fruit (Table 3). Natural dates contained slightly more fructose and glucose than waxy dates. The sugars remained fairly constant during storage and no consistent trends could be established.

TEXTURAL QUALITY. After 5 mo in cold storage peak shear forces (lb/date) for waxy dates from grade A were 15 before storage, and 16 in unlined and 20 in lined bins. Peak shear forces for No. 1 dry dates from grade B were 18 before storage, and 22 in unlined and 19 lb/date in lined bins after 5 mo. Peak shear forces in lb/date for No. 1 dry and No. 2 dry dates in grade C were, respectively, 22 and 28 before storage, and 22 and 17 in unlined bins and 25 and 29 in lined bins after 5 mo. Consistent trends could not be determined. Results were complicated by the change in proving rings after 2 mo.

SUMMARY

Fifty-four bins of early-, mid-, and late-season Deglet Noor dates are in storage for 12 mo at —3, 2, and 4° C, and 0-5 mo outdoors with subsequent cold storage for 7-12 mo in the same cold storage rooms. After 5 mo in storage under these conditions, only small quality changes in dates were found. The percent by weight of very moist and dry dates decreased and of natural, waxy, and No. 1 dry dates increased. Waxy, No. 1 dry, and No. 2 dry dates increased 1-3 percentage points in moisture content, and 2-3 mg/g in pigment content. A slight inversion of sucrose to fructose and glucose took place in waxy dates. The sugar contents of No. 1 and No. 2 dry dates remained fairly constant. Generally, the shear force required to cut the dates decreased during storage. Moisture, pigment, and sugar content will be deter-

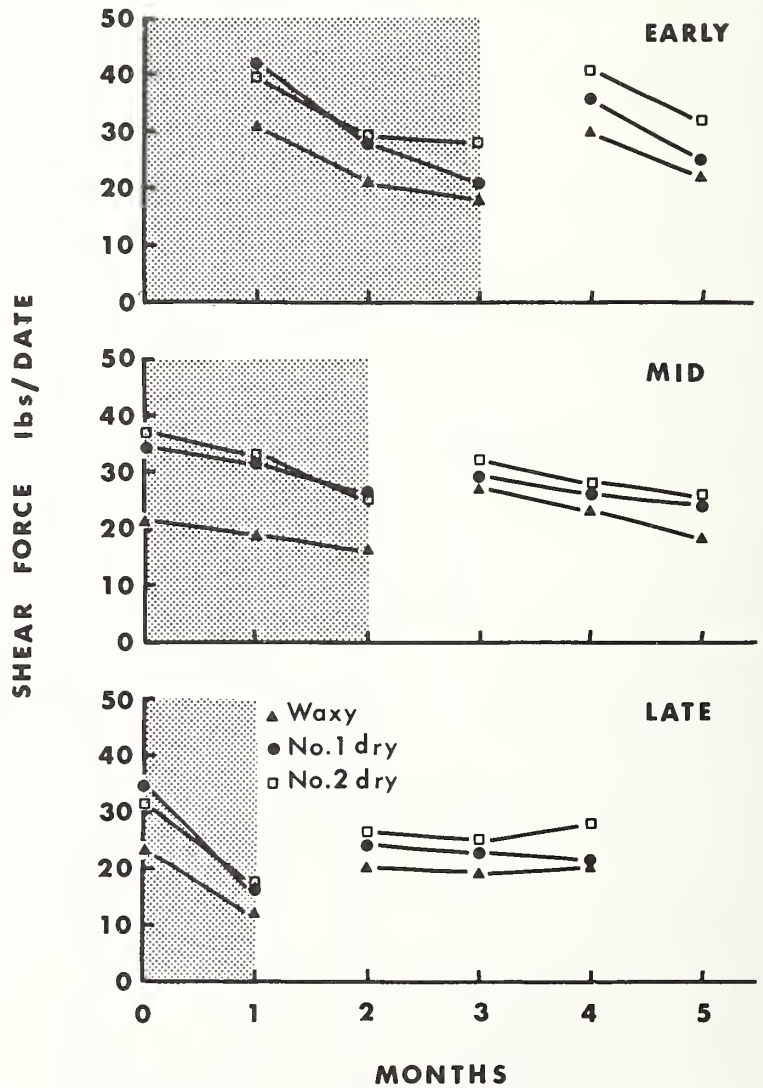

FIG. 4. Shear force as lb/date for waxy, No. 1 dry, and No. 2 dry dates from early-, mid-, and late-season field run fruit stored 5, 5, and 4 mo outdoors, respectively. Values in shaded area are from a 2,500 lb proving ring and values in clear area from a 250 lb ring.

mined as the bins are put into cold storage, after 5 mo in cold storage, and at the end of the 12-mo test. USDA grades and textural quality will be determined each month for the remainder of the test.

Also, 18 bins containing three storage grades of mid-season Deglet Noor dates in conventional open bins and in polyethylene-lined bins are in storage for 12 mo at —3, 2, and 4° C. During 5 mo in storage, a general equilibration took place in USDA grades of these dates as the percent by weight of very moist and dry dates decreased and of natural and waxy dates increased. Moisture content was inconsistent, but usually decreased slightly. Pigment content increased 2-4 mg/g and the sugars remained fairly constant during 5 mo storage. Consistent trends could not be established in the force required to cut the dates. Differences between dates in unlined and lined bins were slight during the storage period. USDA grades, textural quality, and moisture, pigment, and sugar content will be determined each month for the remainder of the 12-mo. test.

ACKNOWLEDGEMENTS

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Mention of a proprietary product in this paper does not constitute a recommendation or an endorsement of the product by the U. S. Department of Agriculture.

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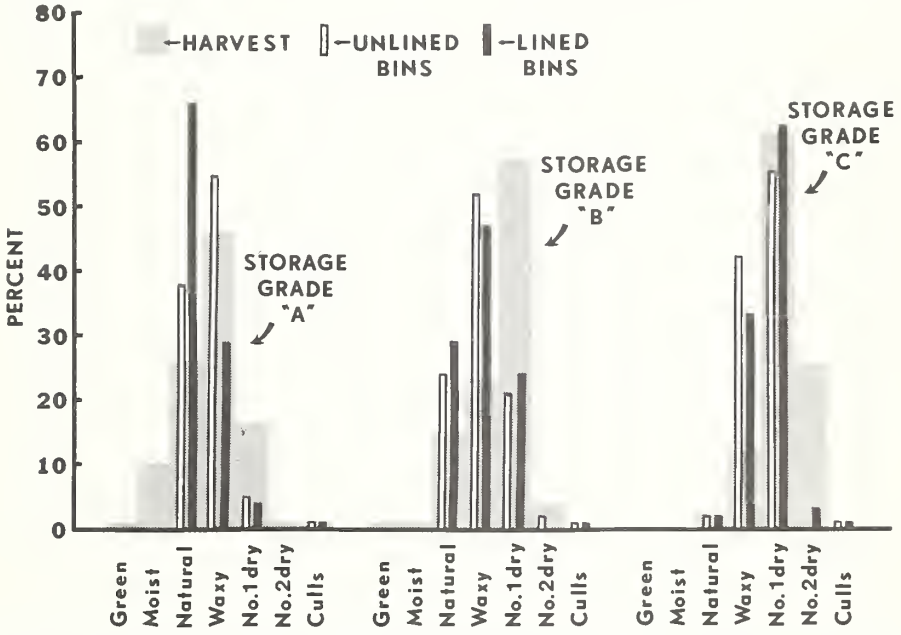

FIG. 5. Grades determined by USDA graders for 3 storage grades of mid-season dates at harvest and after 5 mo storage at —3° to 4° C in unlined and polyethylene-lined bins.

Table 3. Sugar content as percent[1] dry wt of natural, waxy, No. 1 dry, and No. 2 dry dates from three storage grades of dates before and after 3 mo in storage at —3 to 4° C in unlined and polyethylene-lined bins

Storage grade	USDA grade	At harvest			After storage 3 mo			
		Fructose	Glucose	Sucrose	Bin	Fructose	Glucose	Sucrose
		%	%	%		%	%	%
"A"	Natural	12.7±1.5	14.6±0.7	55±10	Unlined	15.3±4.5	14.8±3.8	56±5
					Lined	13.9±1.0	14.7±1.1	53±3
	Waxy	12.0±0.7	13.6±1.1	53±5	Unlined	14.2±2.3	14.4±2.1	55±5
					Lined	13.4±1.5	13.3±1.6	56±1
"B"	No. 1 dry	9.9±0.8	10.6±0.9	58±2	Unlined	8.3±0.7	8.5±0.4	64±1
					Lined	9.5±0.5	9.8±0.8	61±2
"C"	No. 1 dry	10.1±0.6	11.1±0.6	58±2	Unlined	10.0±1.0	10.0±1.1	61±5
					Lined	10.3±0.5	10.5±0.5	58±5
	No. 2 dry	8.3±0.6	9.8±0.8	60±4	Unlined	8.3±0.2	8.4±0.0	65±6
					Lined	9.5±0.4	9.8±0.5	59±7

[1]Values represent the average ± the standard deviation of 6 bins at harvest and 3 bins after storage.

ANALYSIS OF USDA DOOR-GRADE SAMPLING PROCEDURES FOR DATES

PHYLLIS A. NASH AND ROGER M. PERKINS

Statistician and Specialist, respectively, Department of Soil Science and Agricultural Engineering,
University of California, Riverside, California 92502.

ABSTRACT

Six methods of sampling bins of dates (door-grade) received at the packing house are compared. Based on the cost of sample grading, reliability of sampling, variations in date quality among bins, and returns to the growers, it is concluded that each bin received at the packing house should be sampled. A composite sample made from fruit of each bin may be graded by a U. S. Department of Agriculture grader to demine the price paid to a grower.

Date Growers' Inst. Rep. 52:30

Since the advent of mechanical harvesting and the use of bulk bins for handling fruit, growers have been concerned with the reliability of the sampling procedure used to determine payment for fruit received by the packing house. It is important that the sampling procedure be equitable, since fruit loses grower identity once it has been received and sampled.

Cal Date Company was chosen for this study, since the price it pays the grower is based on quantity and quality of all fruit above cull grade. This pricing method is different from that of many independent packers who pay a predetermined price per pound for all fruit, regardless of quality.

The sampling method used by Cal Date Co. through crop year 1974 was as follows: 1) If the load or lot is 9 bins (approximately 800 lb of fruit/bin) or less, each bin is sampled by a bin sampling machine; if more than 9 bins, then half of them are randomly selected for sampling; 2) The method of sampling with the bin sampler is to draw a 30-lb[1] (13.61 kg) core sample at random from 1 of the 8 possible locations in the bin; 3) These 30-lb samples are then reduced to one 30-lb composite sample; 4) A 50-oz (1.42 kg) sample is then drawn by hand by the U. S. Department of Agriculture grader.

The 50-oz sample is graded into standard categories by one of the sample graders and checked by the USDA grader in charge. This checking is done to reduce the inherent variability arising from the subjective nature of many of the criteria which determine the grade for a single fruit. The percentages by weight of the various categories in the 50-oz composite are applied to the entire lot to determine the payment for that lot of fruit.

Due to widespread interest in sampling and its effect on the price paid for dates, we wanted to determine the effect of varying different aspects of the sampling procedure to ascertain whether there is an economical method to estimate closely the true value of field run fruit from a small sample.

METHOD

Ten lots with 18 bins each from one grower were chosen from fruit received at the packing house in December, 1975, and a sampling procedure was established. From each bin in each lot a 30-lb core sample was taken by the bin sampler (2). From each 30-lb core sample a 50-oz sample was drawn and graded. These 18 50-oz samples per lot comprise what we will call the true value of the population (hereafter refered to as true value) for that particular lot.

In addition, a composite sample was made by reducing the fruit left from the 30-lb core samples from each bin down to one 30-lb composite sample for each lot. First, from the composite sample for each lot, six 50-oz samples were drawn, each being drawn, graded, and then returned to the box, and mixed with the other fruit, before a new 50-oz sample was drawn. Next, from each lot a single 100-oz sample was drawn from the 30-lb composite and graded.

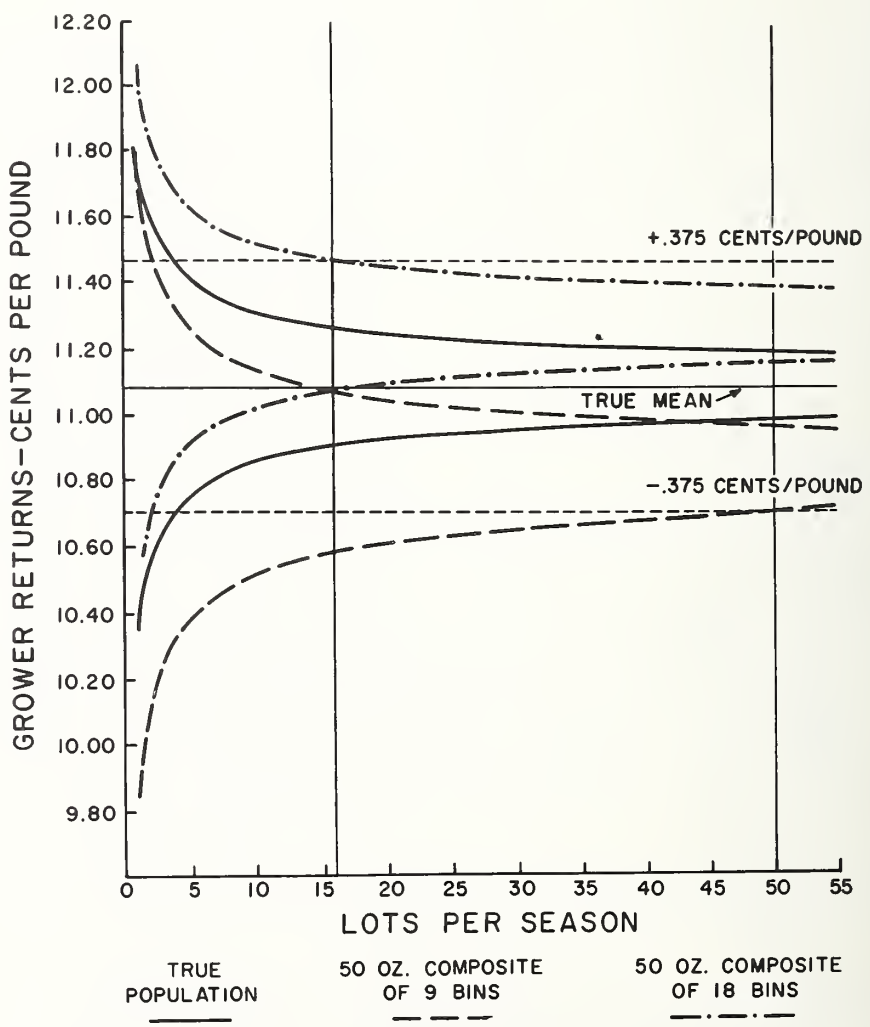

FIG. 1 Comparison of expected limits of the means of the true population, the 50-oz composite of 9 bins, and the 50-oz composite of 18 bins.

[1] Avoirdupois weights are used in the text to accommodate local packinghouse usage.

To determine the variability within a single bin, 30-lb core samples were taken from 10 different locations in 1 bin. Each of the 10 core samples was reduced to one 50-oz sample and all 10 samples were individually graded.

The data obtained from the various sampling procedures were evaluated statistically. Members of certain groups of samples were recombined to form new samples. For each lot and for the average of the 10 lots, the monetary value of each procedure has been compared with the true value.

RESULTS

To show the variability among bins within a lot, two lots were selected from the 10 lots utilized. Table 1 shows both the lot with the least variation and the lot with the greatest variation among bins. The values shown are in cents/lb to the nearest hundreth of a cent based on Cal Date Co. payment to growers for the 1974 crop year. The lot with the least variation had a range of 1.46 cents/lb for the 18 bins, while the lot with the greatest variation had a range of 3.18 cents/lb. In these two lots, as with the remaining eight lots in the test, approximately one-half the bin values fall on each side of the average for that lot.

This even distribution can be attributed to the present mechanical harvesting method, which can also explain the significant within-bin variation in the one bin in which 10 samples were taken and graded. First, since most of the fruit is harvested in a single trip through the orchard, quality of the fruit from each tree varies greatly. Since the inflorescences on a single tree may emerge during a period of a month or more, the fruit will differ in maturity at the time of harvest. The earliest bunches will be somewhat over-mature and dried down, others will probably be near their optimum, and the late bunches may be slightly immature. If all of these bunches are put in the same bin, there will be a wide variation in the quality of fruit in that bin and distribution, with respect to quality, will not be uniform.

TABLE 1. Sample variation among bins within a lot

Bin Number	Values expressed as cents/lb	
	Lot with least variation	Lot with greatest variation
1	10.70	9.30
2	10.76	10.18
3	10.76	10.26
4	10.84	10.46
5	10.86	10.52
6	10.92	10.66
7	10.92	10.82
8	11.00	10.92
9	11.12	11.14
10	11.36	11.14
11	11.42	11.28
12	11.50	11.46
13	11.58	11.58
14	11.76	11.70
15	11.78	11.70
16	11.82	11.72
17	11.86	12.08
18	12.16	12.48
Average of all bins	11.28	11.08
Standard deviation	.46	77
Range	1.46	3.18

A crew harvesting from 4 palms at each set will normally fill 2 bins at each set. The source of fruit in each bin explains some of the large differences among bins in a given lot. Fruit which shatters during cutting of the bunches and dumping of the bunches from the basket into the trailer falls into the rear bin of the shaker trailer; such fruit tends to be drier, lower quality fruit. The fruit which goes into the front bin is that shaken from the bunch and tends to be higher in moisture and of better quality.

Various sampling methods (Table 2) were tried to determine their effect on the reduction of the inherent variability among bins within a lot. The calculated values are shown for each of the 10 lots and the average of the 10 lots by each method. Each value is the grower's return in cents/lb. The percent variation of each average from the true average is also shown for each experimental sampling procedure.

The values for any given lot (Table 2) by any of the sampling procedures may be quite different from the true value for that lot. Column one (Table 2) shows the true values for each of the 10 lots and a 10 lot average of 11.08 cents/lb. This is the standard with which the results of each of the other procedures should be compared.

Column two represents the values obtained from the 50-oz composite of 9 bins, or the sampling of half the bins. Its 10-lot average of 10.82 cents/lb was 2.35% below the true value average.

The third column demonstrates the results of taking a 50-oz composite of 18 bins, its average of 11.27 cents/lb, which is 1.71% above the true value average. The values shown were for the first of the six 50-oz samples from each lot. This method, as compared with a 50-oz, 9-bin composite, requires sampling from twice as many bins, but the grading of only a single 50-oz sample.

The values in the fourth column are those of the single 100-oz composite of 18 bins, which were sampled from each lot. The average value of 10.98 cents/lb was 0.90% below the true value average. This method would both double the number of bins to be sampled and the size of the sample to be graded, as compared with the 50-oz composite of 9 bins.

Column five represents the 100-oz com-

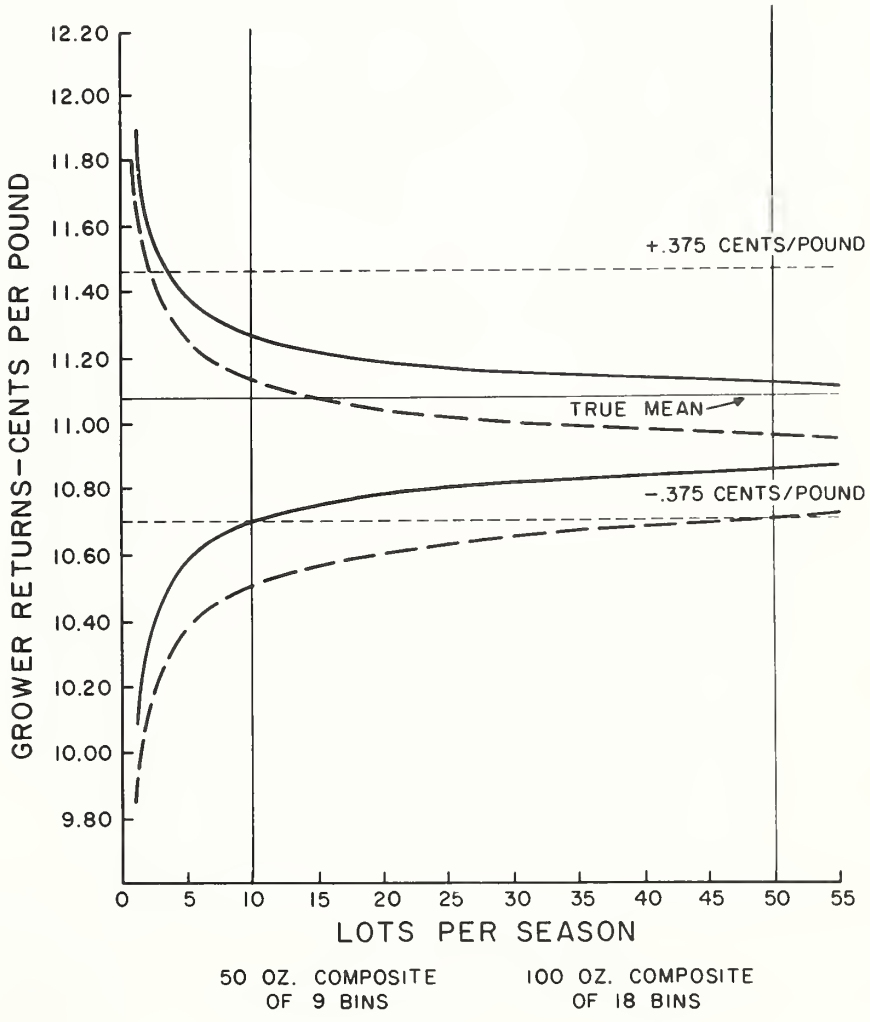

FIG. 2. Comparison of expected limits of the means of the 50-oz composite of 9 bins and the 100-oz composite of 18 bins.

TABLE 2. Influence of various sampling procedures on grower returns

Lot number	True value	50-oz composite of 9 bins	50-oz composite of 18 bins	100-oz composite of 18 bins	Two 50-oz random samples (avg)	Four 50-oz random samples (avg)	Six 50-oz samples (avg)
	Values expressed as cents/lb						
1	11.08	11.04	11.42	11.11	11.54	11.50	11.54
2	11.65	11.56	11.84	11.50	11.70	11.80	11.84
3	10.71	10.06	11.10	10.71	11.13	11.06	11.09
4	11.21	11.48	10.92	11.33	10.89	11.16	11.01
5	10.50	10.10	10.54	10.05	10.44	10.58	10.59
6	11.41	10.74	11.66	11.16	11.29	11.22	11.15
7	11.04	10.68	11.54	10.76	10.18	10.40	10.46
8	10.59	10.66	10.84	10.56	10.62	10.54	10.65
9	11.28	10.98	11.26	11.10	10.66	10.81	10.86
10	11.31	11.00	11.54	11.54	11.51	11.56	11.43
Average	11.08	10.82	11.27	10.98	11.00	11.06	11.06
Average percent variation from true		−2.35%	+1.71%	−.90%	−.72%	−.18%	−.18%

posite of 18 bins and its average of 11.00 cents/lb, which is 0.72% below the true value average. This procedure, unlike that represented in the fourth column, was obtained by combining two 50-oz samples, which were actual graded samples. A random number generator was used to select two of the six 50-oz samples from each lot. The restriction was placed such that the second draw could not be the same sample as the first. This process was repeated a second time; however, these values are not shown. The results of a combination of the two tries at drawing two 50-oz samples are shown in column 6.

Column 6 represents the grading of four 50-oz samples. Its average value was 11.06 cents/lb, which is 0.18% below the true value average.

The last column shows the averages of the six 50-oz samples from each of the 10 lots and its average of 11.06 cents/lb, which is 0.18% below the true average. Comparing the average of the last column with the average of the third column shows that the first draw of the six 50-oz samples contained a greater amount of the higher quality fruit. There was an equal chance on the first draw of getting low quality fruit as well as fruit very close to the true value average. The variations that may be expected to occur among certain of the proposed sampling methods, as determined by statistical calculations on the 10 lots, are shown in Fig. 1, 2 and 3. The amount of expected variation by any method becomes less as the number of lots per season increases.

At the 95% confidence level, we can determine the limit of the error (3) by the equation $L = 1.96\ \sigma/\sqrt{N}$, where σ is the population standard deviation (which is estimated from the sample standard deviation from the lot samples), N is the number of lots and L is the amount of expected variation from the mean. Use of this equation can establish both an upper and lower limit for each procedure for a given number of lots per season. Curves have been drawn through these series of points and we can be 95% confident that the true mean will fall between the pair of curves representing each procedure. Horizontal lines have been drawn to represent .375 cent/lb on either side of the true mean of the 10 lots. This amount of variation has been suggested as an acceptable amount by Cal Date Co. management.

Figure 1 shows a comparison of the limits of the means of the true values with those of the 50-oz composite of 9 bins and the 50-oz composite of 18 bins. With the 50-oz 9-bin composite, a grower needs 50 lots per season to be within .375 cent/lb of the true mean, whereas with the 50-oz, 18-bin composite, the grower needs only 16 lots per season to be within the same margin, a 68% decrease in the number of lots needed to be within an acceptable margin. Seventy percent of the total tonnage is produced by growers delivering 16 lots or more per season, while only 20% of the total tonnage is received from growers delivering more than 50 lots per season. Changing from a 50-oz composite of 9 bins to the 50-oz composite of 18 bins would result in a 50% increase of the total tonnage received, which would be within the acceptable limits. The 50-oz composite of 18 bins would double the number of samples drawn by the bin sampler and thus increase the total USDA sampling cost by 30%.

Accuracy may be increased by using a 100-oz composite of 18 bins. Figure 2 shows a comparison of the curves representing the expected variation of the 50-oz composite of 9 bins and the 100-oz composite of 18 bins. This graph shows that with the 100-oz composite of 18 bins we will be within .375 cent/lb of the true mean at 10 lots per season. Eighty percent of the total tonnage is produced by growers delivering 10 or more lots per season. The 100-oz composite of 18 bins would result in an 80% decrease in the number of lots

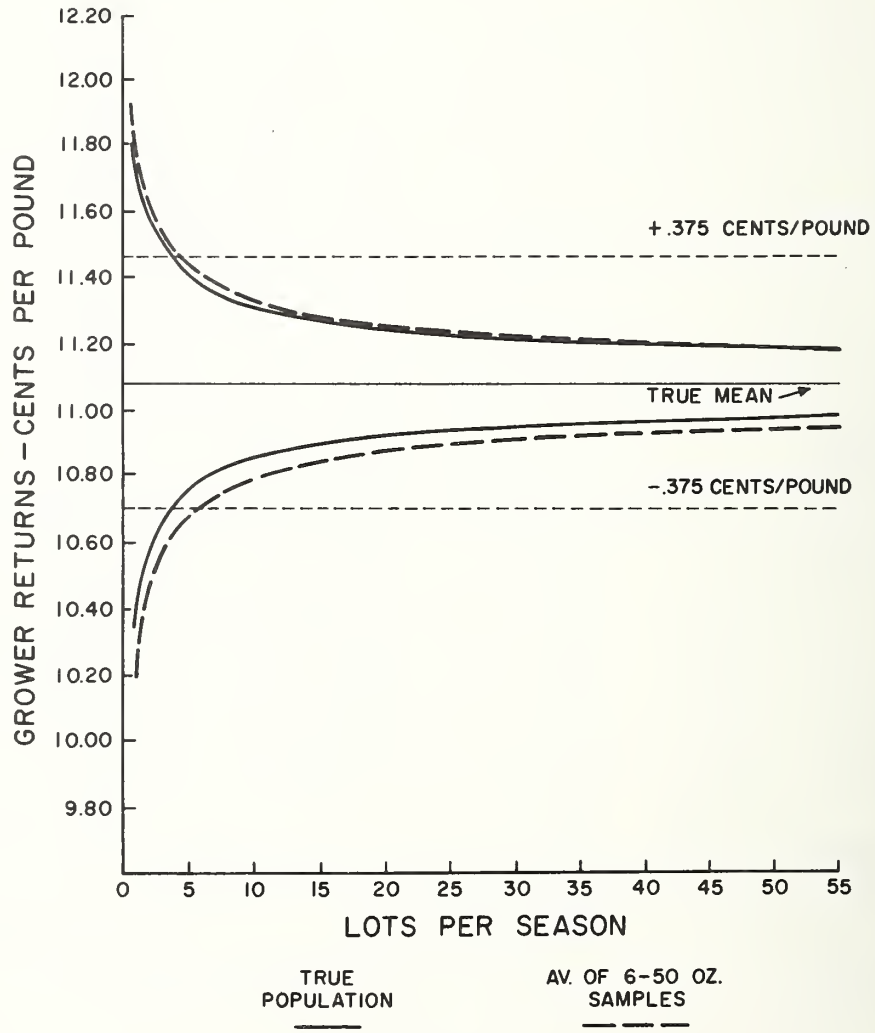

FIG. 3. Comparison of expected limits of the means of the true population and the average of six 50-oz samples.

needed to be within acceptable limits, as compared with the 50-oz composite of 9 bins. This decrease would require doubling the number of bins sampled and grading twice as large a sample, which would result in an increased total USDA sampling cost of 68%.

Since 70% of the total tonnage is produced by growers delivering 16 or more lots per season, a change from the 50-oz composite of 18 bins to the 100-oz. composite of 18 bins would result in only a 10% increase in the total tonnage delivered within acceptable limits, while increasing total USDA sampling costs by 38%.

Figure 3 shows a comparison of curves representing the true values and those representing the six 50-oz composite of 18 bins. It can be seen how closely the curves for the six 50-oz composite of 18 bins follow the curves showing the variation for the true values. This result shows that the 30-lb composite of 18 bins is an adequate sample of the lot (1).

CONCLUSION

The sampling procedure used in the past and all the proposed methods may vary considerably from the true value for a given lot; however, we should be more concerned with the annual grower returns. True accuracy for a single lot can only be obtained by grading a considerable portion of the fruit from each bin in the lot, and this is not economically feasible.

While some of the methods discussed are quite close to the true values, such as six 50-oz samples from an 18-bin composite, or grading four 50-oz samples per lot, these methods must be discarded on the basis of USDA sampling costs. The single 100-oz composite of 18 bins, while more accurate, was not a large enough improvement over the 50-oz composite of 18 bins to justify the increase of sampling costs.

The variation of the quality of fruit between bins is considered to be the reason for the discrepancy between the true average of our 10 lots of 11.08 cents/lb and the 50-oz composite of 9 bins average of 10.82 cents/lb. We conclude that a sample should be taken from each bin and the composite made from fruit from all bins in a lot. These results were discussed with Cal Date Co., and starting in crop year 1975, the sample used to determine a growers' returns will be a 50-oz composite made from all bins in each lot.

By any proposed sampling method other than the 50-oz, 9-bin composite, a grower having 16 lots or more can expect to be within .375 cent/lb of the true value of his fruit for his yearly returns. This amount of variation was determined to be acceptable by Cal Date Co. A grower's yearly returns may fall below the true value by this much, or they may be above the true value by this amount. While a grower delivering less than 16 lots of fruit per season can expect a greater amount of variation on a seasonal basis, if he delivers 5 lots of fruit per season for 3 yr, he is still delivering 15 lots of fruit; therefore his net returns should average out within the acceptable limits over a 3-yr period.

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MECHANIZATION OF DATE CULTURAL PRACTICES

JAMES F. WRIGHT

Desert Date Sales and Packing Company, Indio, California 92201.

ABSTRACT

Mechanization of harvesting, pesticide application, pollination and pollen extraction in date palm culture is reviewed briefly. The California date industry now operates with only 20-25% of the labor force required in the early 1960's.

Date Growers' Inst. Rep. 52:34

Like many other California farming industries, the California date industry to a large degree relied on the Mexican bracero program in the 1950's and early 1960's. It was common for date growers to request 1,500 to 1,800 braceros as pickers in September. Little effort was made to mechanize date harvesting because ample labor was available at reasonable cost. Fortunately, a few persons saw the possibility of the loss of the bracero program and in the late 1950's studies on mechanization of date harvesting were started.

The most difficult job to a new date worker is the moving of a 50-ft ladder from one tree to another, so it was natural that the first step in mechanization was to position the workers in the tree by a mechanical lift. This was helpful in getting the worker in to the crown of the tree, but resulted in no savings in cost.

In the fall of 1961, the U. S. Department of Agriculture and University of California agricultural engineers started cooperative work on mechanization research. During 1961, 1962, and 1963, various kinds of harvesting equipment were developed and tested.

I would like to point out that by that time the California date industry had enough people who were interested in, and saw the need for, mechanization so that the agricultural engineers had a climate in which they could operate effectively.

Mechanization required many changes. Fortunately, a few growers and the California Date Growers' Association (which had a large field department) were willing to make the changes.

Commercial, mechanical harvesting began in 1964 and advanced quickly. By means of a boom, a worker was positioned in the palm. The fruit bunches were cut and lowered to the ground and the fruit was shaken mechanically into boxes or bins.

The agricultural engineers tackled mechanical pollination and helped solve this problem. Mechanical pollination requires the use of more pollen than hand pollination. The next project was development of a pollen extractor, work on which was completed in 1974. A commercial model was put to use in 1975.

All of these developments took place over a period of approximately 15 yr. Through mechanization of harvesting, pesticide application, pollination, and pollen extraction, the California date industry can now operate with only 20-25% of the labor force required in the early 1960's This is important, for we still have difficulty in obtaining workers. Survival of the date industry has depended to a great extent on mechanization.

MEMBERSHIP ROLL 1975-1976[1]

COMPANY MEMBERS

Alamo Ranch, Inc., (John Keck)
P. O. Drawer FF ..... Indio

Calavo Growers of California
(John Killifer, Mgr., Process Products Div.)
4833 Everett Ave. ..... Vernon

California Date Administrative Committee
(Earl Asker)
P. O. Box 764 ..... Indio

Cal-Date Company
P. O. Drawer HHH ..... Indio

California Redi-date, Inc.
(Asel Eoff and W. M. Jeffry)
P. O. Box 816 ..... Thermal

Coachella Ranches (D. A. Stevning)
51-064 Monroe St. ..... Indio

E. J. Derderian, Elliott Mfg. Co., Inc.
P. O. Box 11277 ..... Fresno

Desert Packing Co., Inc.
P. O. Box 1210 ..... Indio

Francis Date Co.
2125 W. Jackson ..... Phoenix, AZ

Hadley Date Gardens (Walter S. Alf)
83-555 Airport Blvd. ..... Thermal

Royal Medjool Date Ranch
P. O. Box 551 (190 Madison Ave.) ..... Yuma, AZ

Shields Date Garden
80-225 Hwy. 111 ..... Indio

Sun Gold Ranches (Codekas Bros.)
56-220 Jackson St. ..... Thermal

INDIVIDUAL MEMBERS

Al-Bakir, Alaa
23-A Solano Park Apts. ..... Davis

Al-Mehdi, Ali A.
1122 East Adams ..... Tucson, AZ

American Date Gardens
P. O. Box 806 ..... Mecca

Anderson, Lee (Covalda Date Co.)
P. O. Box 908 ..... Coachella

Abd El-Baki, Mamdouk
P. O. Box 769 ..... Cairo, Egypt
(c/o E. J. Derderian, see above)

Blumberg Ranch (Lewis Blumberg)
37-593 Thompson Rd. ..... Rancho Mirage

Brown Date Garden (T. R. Brown)
Route 2, Box 81 ..... Thermal

Carpenter, J. B.
44-455 Clinton St. ..... Indio

Cavanaugh, H. L.
76-353 Hwy. 111 ..... Palm Desert

S. Chuchian Ranch
85-690 Hwy. 111 ..... Coachella

C. V. Fruit Co. (Don Mitchell)
P. O. Box 833 ..... Indio

Davies, John
82-408 Oleander ..... Indio

Dharmasakti, P.
785 Prajak Road ..... Nongkhai, Thailand

W. L. Dixon Co. (Pete Dondero)
81-931 Victoria St. ..... Indio

D. R. M. Growers Assoc. (B. Debonne)
P. O. Box 1935 ..... Palm Desert

Eastes, Ivan
81-882 Avenue 50 ..... Indio

El Mima Date Gardens
P. O. Box 170 ..... Alice Springs, N. T., 5750
Australia

Embleton, T. W.
Dept. of Plant Science
University of California ..... Riverside

Ensley, Harold
Route 1, Box 164 ..... Thermal

FAO-RNEA Library
P. O. Box 2223 ..... Cairo, Egypt

Fish, Ted
Route 2, Box 75 ..... Thermal

Fruit and Food Technology Research Inst.
Private Bag ..... Stellenbosch, C. P.
South Africa

Furr, J. R.
81-242 Alberta Ave. ..... Indio

Government of Western Australia
Librarian, Dept. of Agriculture
Jarrah Road ..... South Perth 6151,
Western Australia

Harley Berryman Farms
P. O. Box 882 ..... Bard

Hilgeman, Robert
Citrus Branch Station
Route 1, Box 715 ..... Tempe, AZ

Hjorth, W. L.
80-950 Ave. 49 ..... Indio

Hull, Mrs. Leslie K.
22 Fourth Ave., N. E. ..... Waukon, Iowa

Jarvis, E. C.
Route 1, Box 180 ..... Thermal

Kalra, S. K.
Punjab Agricultural University
Regional Fruit Research Station .. Abohar 152116, India

Kuklinsky, Paul
Purple Hills Ranch of Oasis, CA.
39 White Oak Road ..... Wellesley, Mass.

Last, Michael W.
Pukatja Community Inc. .. Ernabella, Via Alice Springs,
N. T., Australia

Leach, George
Route 2, Box 167 ..... Thermal

Lindgren, David L.
Dept of Entomology
University of California ..... Riverside

Loud, A. R.
P. O. Box 2039 ..... Pomona

Marshburn Farms (Karl Kelsey)
Route 2, Box 255 ..... Thermal

Mitchell, David
P. O. Box 833 ..... Indio

McLeod, Rose L.
P. O. Box 31 ..... Colville, Washington

[1]All addresses California unless otherwise specified.

INDIVIDUAL MEMBERS (Continued)

Newcomb, D. A.
Route 2, Box 72 ..... Thermal

Nicoll, R. C.
Valerie Jean Date Shop
P. O. Box 786 ..... Thermal

Nixon, R. W. (Deceased)
81-229 Palmyra Ave. ..... Indio

Nordland, Olaf
81-487 Alberta Ave. ..... Indio

Osman, Awad M. A.
Hudeiba Research Station ..... El Dammer, Sudan

Patterson, K. K.
81-370 Date Palm Ave. ..... Indio

Ream, Charles L.
27 Diamond E ..... Palm Desert

Reuveni, Oded
Agricultural Research Organization
The Volcani Center
P. O. Box 6 ..... Bet Dagan, Israel

Robinson, Donald
P. O. Box 1751 ..... Indio

Schmid, Walter
7931 Sampson Ave. ..... Garden Grove

Smead, Paul
Route 2, Box 60 ..... Thermal

Sniff, Stanley L., Jr.
P. O. Drawer S ..... Indio

Swingle, Leonhardt
44-566 Swingle Ave. ..... Indio

Swingle, Mrs. W. T.
3400 Laguna St., No. 309 ..... San Francisco

Universidad de Sonora
Escuela de Agricultura y Ganaderia
Apartado Postal 305 ..... Hermosillo, Sonora, Mexico

Vincent, Lloyd E.
Dept. of Entomology
University of California ..... Riverside